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## NOTES AND COMMENTS.

### Internally-Chilled Castings.

In the last issue of THE FOUNDRY TRADE JOURNAL we commented upon the phenomenon of inverted chilled castings which were commonly encountered in German foundry practice towards the end of the war. Mr. C. A. Heise, of Berlin, writing in a recent issue of the "Iron Age," gives an explanation and solution of the difficulty. He states:—

"It was held by some authorities that the reversed order of layers was primarily due to a high content of phosphorus, but this view proved incorrect, since the same feature was observed in castings, the analysis of which showed a normal phosphorus content. In all cases, however, the Baumann sulphur pressure-test pointed to an exceptionally high sulphur-content and a correspondingly low carbon and manganese content, and at last a clue was found. While sulphur usually occurs in form of manganese sulphide, the low manganese-content of the castings caused the surplus sulphur to enter a chemical combination with the iron. Sulphide of iron, however, melts at 950 deg. C. and the separation of the gases when cooling down was found to prevent a separation of the graphite which in any case is already greatly reduced by the presence of sulphur. Owing to its relatively low melting-point, the sulphide concentrates at the core of the casting, as the result of which white cast-iron is produced.

"With a view of counteracting the "inversion" effects, an increase of the manganese content is suggested, since manganese sulphide has a higher melting point than iron, manganese or iron sulphide. An increase in the lime percentage as well as caution in the use of oxidised scrap is also recommended."

We have received a letter from Mr. W. H. Poole, controller of the Keighley Laboratories, Ltd., who has recently investigated samples of cast-iron exhibiting this phenomenon, and he has kindly promised to embody his results in an article to be presented to the readers of THE FOUNDRY TRADE JOURNAL.

### Proposed Foundry Exhibition at Birmingham.

In connection with the Annual Convention of the Institution of British Foundrymen, to be held at Birmingham in July, 1922, it is intended to hold a large exhibition of foundry plant, appliances, manufactured goods, etc. An influential committee has been formed who already have made all preliminary arrangements. The exhibition is intended to be international, with exhibits from America, France, Belgium, and England, both in the ferrous and non-ferrous trades, and as this will be the first attempt to hold such an exhibition, every effort will be made to make it as interesting as possible, not only will the exhibition display all modern foundry plant, but the programme will include model foundries at work, core making, pattern making, etc. For the first time in British foundry history, every possible phase of foundry work will be brought together.

The exhibition is being organised by Mr. T. Vickers, of Central House, New Street, Birmingham—the Secretary of the British Cast Iron Research Association.

### The Growth of the Drop-Forging Industry.

What can be expected in the way of competition against steel castings is revealed by an article by Mr. Arthur Stubbs in the first number of the "Drop Forger," wherein he states that considerable progress has been made in the last six years, firstly in the number of drop hammers installed, secondly in the increase in the heavier type of hammer, *i.e.*, 4 tons falling weight and over, and thirdly in the extent to which steel and malleable castings have been superseded.

It is estimated that there are to-day more than twice the number of drop hammers installed than there were operating in 1914, while the largest drop hammer in service in 1914 was of 4½ tons capacity, whereas to-day friction drop hammers having a 6 ton tup, which together with the weight of the top die represents a falling weight of 9½ tons, are in use, while steam drop hammers, having tups weighing 5 tons have been installed in a number of plants. A steam drop hammer of 10 tons capacity has also been constructed.

A comparison of the output per man employed in the drop-forging industry during the war, together with the output per man to-day, while in some respects it might be misleading having regard to the long runs or numbers of a given part ordered during the war as compared with to-day's requirements, which are much smaller, would be very instructive. The maximum output per man per week over a period of 13 weeks was reached in the quarter ending March, 1917, which was 0.47 tons.



XUM

# Cupola Design.

Some interesting details regarding the design of cupolas were recently given in an article by Mr. Y. A. Dyer in the "Iron Age," of which the following is an extract:—

Under the most favourable physical and chemical working conditions the net results of foundry operations, measured in efficiency of the cupola, approximate only 50 per cent. As the conditions which create the 50 per cent. of unused energy are still beyond the power of man to control, those conditions which enable the foundryman to approximate and maintain an efficiency of 50 per cent. in cupola operations are the ones with which he is at present concerned.

As a matter of convenience, cupola sizes may be designated as small, medium, and large—small sizes ranging from 24 to 42 in., inclusive; medium sizes from 44 to 62 in., inclusive; and large sizes from 64 to 90 in., inclusive. This classification may be based on graduated maximum tuyere area ratios to cupola areas. That is: 1:5 and fractional ratios end at 42 in.; 1:6 and fractional ratios end at 62 in.; 1:7 and fractional ratios end at 82 in; and 1:8 to 1:8.3 ratios end at 90 in., the arbitrary maximum large-size cupola.

In the construction or remodelling of a cupola there are vital factors to be seriously considered. First, the size (with reference to lining diameter) necessary to perform specific tonnage duty under prescribed conditions; second, the height (measured from bottom to charging door) necessary for efficient and economical operation; third, the number, size, and location of tuyeres necessary to supply sufficient air or oxygen for reasonably complete combustion of fuel; fourth, balanced areas for blast-pipe and windbox; fifth, the capacity and kind of blower for supplying air. These two last-named factors are essential to fix the delivery of a proper quantity of air with minimum friction and equal distribution in the cupola.

Due regard should be accorded every detail of construction. The thickness of steel shell may vary with the size of cupola, but in each case largely determines the permanency of the unit installed. The inside diameter, measured at the melting zone, should serve as a guide for rational hourly melting capacity, though at times this factor is disregarded for expediency of output—but not without paying the penalty. A case in point will serve aptly to illustrate this feature:—

Should an installation of 32-in. cupola be decided on, with 149 sq. in. tuyere area, 10½-in. blast main, and 261 sq. in. windbox area (rated melting capacity approximately 3½ tons per hour), and within a short time prove inadequate to deal with a greater output, the tendency probably would be to speed up the blower and charge more iron and coke in an attempt to force a production of 4¼ to 4½ tons per hour, the rated duty of a 36-in. cupola with 180 sq. in. tuyere area, 12-in. blastpipe, and 336 sq. in. windbox area. The net result would be an abortion of conditions and decreased quality of metal. Possible expansion of business should therefore be broadly estimated when selecting the size of a cupola for specific work.

Some foundrymen anticipate these conditions by installing a so-called "elastic" cupola, such as a shell capable of accommodating a lining contracted to 36 in. or expanded to 44 in. This is by far the more rational plan of the two, provided other ratios are made sufficiently elastic. In this instance it would be advisable to install a 13½-in. blastpipe, an 8½- by 48-in. windbox, provide tuyeres for each diameter as changed from 36 to 44 in., and install a blower capable of delivering a minimum of 2,500 cub. ft. and maximum of 3,500 cub. ft. of air per minute, or the usual type of alternately-driven positive blower which will deliver 13 to 14 cub. ft per revolution. This precaution will minimise the temptation of some melters to overdrive a cupola of small ratio areas or underdrive a large one, and thereby eliminate the ill effects of such practice in melting conditions.

There is also one feature connected with cupola construction which, in a large number of cases, seems to be treated as entirely extraneous to operations—the charging platform. Generally speaking, if the foundryman would multiply by 3 what he considers ample space, there might be a decent area created. For hand-charging operations the platform space should be large enough to accommodate at least surplus coke and flux pile, and all the iron and scrap charges necessary for 1½ to 2 hours' operation. This provision will not only economise in labour, but tend to more uniform and careful charging, as well as keep the cupola filled throughout the charging period.

Many fancy cupola designs have been used, practically and experimentally, but equally as many times cupola builders and operators have drifted back to the old straight-line type, with uniform diameter from bottom to charging door. In substantiation of the soundness of this design, the foundryman has but to remember that the function of the cupola is to melt metallic iron, not to reduce iron oxide. The hot cupola gas is a quick-acting positive melter, compared with the gases produced by complicated chemical reactions in a blast furnace, and which are necessary to prepare the great mass of stock for reduction and melting.

Experience teaches that flared tuyere boxes—say 4 by 8 in. entrance end and 4 by 15¼ in. discharge end (dimensions for 52-in. cupola)—permit the air to enter the cupola under mild rather than piercing pressure (which latter condition accompanies the use of small round tuyeres), thus supplying the proper volume of air and at minimum pressure for each size cupola. The flared ends of one tuyere may extend to within 1 in. of neighbouring tuyeres, or they may be jamb with each other—forming a continuous tuyere band around the entire circumference of the cupola. The author also believes that the straightway entrance of tuyere from bustlepipe into cupola is preferable for the air travel, to the circuitous and deflected goose-neck route, notwithstanding the fact of some less danger of slag and iron entering the windbox through the latter construction. The goose-neck creates a sharp double elbow effect and consequently intensifies friction.

There is no redeeming feature which may be advanced for a double row of tuyeres. They serve only to thwart a stable melting zone. Tuyeres should not be inclined downward through the cupola wall, for this would tend to deflect the blast to the hearth and accentuate the cooling effect on slag and iron. The number and size of tuyeres as related to cupola and blastpipe areas will determine the delivery and distribution of air, or oxygen, on graduated scale of pressure—low, mild, medium-mild, and high—for proper penetration of the stock and combustion of coke to melt the iron, and minimise oxidation.

The position of tuyeres will determine the size of coke bed and regulate the absorption by the iron of certain elements from the coke. Low tuyeres facilitate continuous melting and minimise coke consumption. By the use of a comparatively thin coke bed the molten metal will absorb less sulphur from the coke in its descent to the hearth, lose less heat by coming in shorter contact with low-temperature coke, and absorb less carbon, thereby tending to lower the total carbon content of the metal.

*Area Ratio of Tuyeres.*—In proportion to size of cupola the ratio of tuyere area should decrease with increase of cupola area. That is, the tuyere area of a 24-in. cupola may be 20 per cent. of the cupola area, while the tuyere area of a 90-in. cupola may be only slightly more than 12 per cent. As related to blast-pipe area the proportions reverse. That is, the blast-pipe area of a 24-in. cupola may be practically only 56 per cent. of the tuyere area, while the blastpipe area of a 90-in. cupola may be 92 per cent. of the tuyere area.

The logic of these interdependent areas will be appreciated when viewed from the standpoint of penetration of blast, which will be further discussed in connection with blast-main areas. The ratio of combined tuyere area to cupola area may range by fractional gradation from 1:5 to 1:6 in small sizes, 24 to 42 in.; 1:6 to 1:7 in medium sizes, 44 to 62 in.; and 1:7 to 1:8.3 in large sizes, 64 to 90 in.

The blower should be situated near the cupola to eliminate lengthy blastpipe connections, and to exclude all possible joints. The blastpipe area should not be contracted at any point between blower and windbox except at blower nozzle. Any

intermediate contraction will create additional frictional resistance to the passage of air.

*Blowpipe Areas.*—The ratio of blowpipe area to tuyere area may range by fractional gradation from 1 : 1.78 to 1 : 1.56 in small-size cupolas; 1 : 1.54 to 1 : 1.36 in medium sizes; and 1 : 1.34 to 1 : 1.08 in large sizes. The logic of these ratios will be appreciated from the fact that small cupolas need less relative penetration of blast than larger ones. In other words: the blast from a 12-in. pipe, or 112 sq. in. area, entering a 36-in. cupola through combined tuyere area of 180 sq. in. will be inclined to flow with low pressure, provided inside conditions are normal. This condition is best suited for a small cupola by reason of the air having to penetrate only 18 in. on either side of cupola to reach the centre.

On the contrary, the blast from a 23⅝-in. pipe, or 436 sq. in. area, entering a 72-in. cupola through combined tuyere area of 550 sq. in., will flow with relatively greater pressure under similar conditions. This situation suits a large cupola because the air has to penetrate 36 in. on either side of cupola to reach the centre. The author prefers the entrance of the blast main to windbox to be at a horizontal tangent, and one side only.

*Windbox Area.*—The windbox or bustlepipe area is related to the blowpipe area. The box should be large enough to serve as an air-compressor reservoir to supply the tuyeres—performing the duties of minimising pulsations, freeing tuyere entrances of coke and other obstructions, and reducing the danger of tuyeres immediately in front of blastpipe entrance, passing more air than the more distant tuyeres. The ratio of windbox area to blowpipe area may be 3:1 for all size cupolas, or may be increased to 3.5:1, or even 4:1, for the larger cupolas. But from an economic standpoint the ratio should not be less than 3:1. A windbox may be riveted to shell in box shape. The author prefers one which extends from bottom of the cupola upwards and joined by a bevel edge to upper shell.

### Height of Cupola.

Cupola height is an economic feature independent of any definite scientific ratio. And as the melting zone in large cupolas operated under rationally proportioned areas and adequate accessories may be 12 to 18 in. higher than in small cupolas—on account of necessarily increased pressure—the resultant decrease in free charging height may be avoided by increasing the height of the charging door above the sand bottom.

Therefore, it may be arbitrarily stated, largely as an economic condition, that the height of small cupolas may be at least sufficient to receive 6 to 8 ft. of stock before turning blast on; medium cupolas 9 to 10 ft. of stock; and large cupolas 11 to 14 ft. of stock—hence the ratio of height as related to cupola diameter, where tuyeres are located 16 to 18 in. above the bottom, may vary from 4.5:1 to 3.4:1 in small cupolas; 3.4:1 to 2.8:1 in medium cupolas; and 2.8:1 to 2.4:1 in large cupolas. If very low tuyeres, 6 to 8 in. above bottom should be used for continuous melting. Of course, the height of the door may be raised 6 to 8 ft. for small cupolas to 10 to 12 ft. for larger sizes. By reason of relatively lower gas velocities in the smaller cupolas, the height need not be so great.

Approximately 30,000 cub. ft. of air, free from the blower, is required to supply adequate oxygen in the cupola for combustion of average foundry coke (depending on its carbon content) to melt one ton of metal. It is therefore essential that the cupola blower be large enough to supply this quantity of air regardless of diameter of the cupola used. The positive (pressure type) blower is very desirable, and the blast meter or pitot's tube, for registering air volume, is a valuable adjunct to facilitate scientific operations and guard against repeated inequalities of air delivery—a condition which sometimes exists by reason of variation in revolutions of the blower, especially with electric power.

While the blower should be placed within reasonable distance of the cupola, it should be located where a supply of fresh, clean air can be maintained. The nozzle connection may be 2 to 4 in. smaller in diameter than the blast pipe. The blower should be selected to secure air requirements at a minimum speed.

Thus, suppose a No. 3 blower will deliver 2,500 cub. ft. of air per minute at 325 r.p.m. (7.7 cub. ft. per revolution) by application of 8.5 h.p. at the shaft for 1 lb. pressure and a No. 4 blower the same quantity at 205 r.p.m. (12.2 cub. ft. per revolution) with the same power. Then the saving in wear and tear from vibration by using the No. 4 will more than compensate for the small difference in price between the two machines. The capacity of blower needed for each size cupola may be computed from the charging and melting data. The power at the shaft for 1 lb. pressure will range from 3.5 to 16 h.p. for small-size cupolas; 20 to 36 for medium sizes; and 40 to 76 for large sizes—depending on the size and make of blowers.

*Regulation of Air Delivery.*—If it should become necessary to reduce the air delivery, by reason of a single speed blower of too large capacity having been installed, a properly constructed check valve (of easy and positive control) should be placed on windpipe near cupola and an automatic controlled air vent, of butterfly type, at a convenient point to regulate the air delivery as nearly as possible. This is at best a poor makeshift, and it would be preferable to provide a blower of adequate capacity for the particular cupola installed, rather than attempt to regulate the air delivery other than by a variable-speed motor.

Securing adequate blowing facilities is easy, but the good effects of a well-designed blower may be nullified by lack of equally well designed accessories with which to direct the air effectively into the cupola. Based on a 66-in. cupola, the following specifications illustrate the working of rational air delivery ratios:—Air main area, 364 sq. in.; windbox area, 1,092 sq. in.; tuyere area, 481 sq. in.; cupola area, 3,421 sq. in.

The logical principle becomes at once apparent—that of the air passing from a blower through a 364 sq. in. area air main, into a 1,092 sq. in. area windbox, which serves as reservoir to distribute the air evenly through a combined tuyere area of 481 sq. in into cupola area of 3,421 sq. in. Thus the delivery of a steady and sufficient volume of compressed air is provided, with ample pressure to penetrate the stock to a distance of 33 in. on either side to the centre of the cupola.

TABLE I.—*Suggested Data for Designing or Re-modelling a Cupola.*

| Cupola. Lined diameter. In. | Height. Bottom to charging door. Ft. In. | Tuyeres. No. | Tuyeres. Size : In. | Blast pipe. diameter. In. | Windbox. size : In. |
|---|---|---|---|---|---|
| 24 | 9 0 | 5 | 3 × 6 × 14 | 8 | 6 × 25 |
| 26 | 9 6 | 5 | 3½ × 6 × 15½ | 8½ | 6 × 28½ |
| 28 | 10 0 | 5 | 3½ × 6½ × 16½ | 9½ | 6½ × 32½ |
| 30 | 10 6 | 6 | 3½ × 6½ × 14½ | 10 | 6½ × 36 |
| 32 | 10 6 | 6 | 3½ × 7 × 15½ | 10½ | 6½ × 38½ |
| 34 | 11 0 | 6 | 3½ × 6½ × 16½ | 11½ | 7 × 42 |
| 36 | 11 0 | 7 | 3½ × 7½ × 15½ | 12 | 7½ × 44½ |
| 38 | 11 6 | 7 | 3½ × 7½ × 16½ | 12½ | 8 × 47 |
| 40 | 11 6 | 7 | 3½ × 8½ × 16½ | 13½ | 8½ × 48½ |
| 42 | 12 0 | 7 | 4 × 8½ × 17½ | 13½ | 9 × 50 |
| 44 | 12 0 | 8 | 3½ × 8½ × 16½ | 14½ | 9½ × 52 |
| 46 | 12 6 | 8 | 4 × 8½ × 17½ | 15½ | 10 × 54 |
| 48 | 12 6 | 8 | 4 × 9 × 17½ | 15½ | 10½ × 56½ |
| 50 | 13 0 | 8 | 4 × 10 × 18½ | 16½ | 10½ × 59½ |
| 52 | 13 0 | 10 | 4 × 8 × 15½ | 16½ | 11 × 60 |
| 54 | 13 6 | 10 | 4 × 8½ × 15½ | 17½ | 11½ × 62½ |
| 56 | 13 6 | 10 | 4 × 9½ × 16½ | 18½ | 12 × 65½ |
| 58 | 14 0 | 10 | 4 × 9½ × 17½ | 18½ | 12½ × 68½ |
| 60 | 14 0 | 10 | 4 × 10½ × 17½ | 19½ | 13 × 69½ |
| 64 | 15 0 | 11 | 4 × 10½ × 17½ | 20½ | 14½ × 69½ |
| 66 | 15 6 | 11 | 4 × 10½ × 17½ | 21½ | 15½ × 70 |
| 68 | 15 6 | 12 | 4 × 10½ × 17½ | 22½ | 15½ × 75 |
| 72 | 16 0 | 12 | 4 × 11½ × 17½ | 23½ | 16 × 80½ |
| 78 | 17 0 | 13 | 4½ × 10 × 17½ | 25½ | 16 × 96½ |
| 80 | 17 0 | 14 | 5 × 9½ × 16½ | 26½ | 16½ × 99 |
| 84 | 17 6 | 14 | 5 × 10 × 17½ | 27½ | 17 × 107 |
| 90 | 18 6 | 15 | 5 × 10½ × 17½ | 30 | 17 × 124½ |

*Tuyere, Blastpipe, Windbox and Height Data.*—Table I. may serve as a guide for the construction of a cupola, or preparation of specifications for purchase from a manufacturer, or remodelling of an old cupola. Intermediate sizes may be computed according to the same relative ratios. Heights may be raised if continuous melting is to be the process.

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The British Consul at Malaga reports that a hematite property in the South of Spain covering some 665 acres, and estimated to contain a seam 4½ to 6½ ft. thick, is offered on a royalty basis for a term of years. The analysis of the ore is given as:—Iron, 48-55 per cent; manganese, 3 to 6 per cent.; slight traces of phosphorus and sulphur, but no arsenic or copper. Further particulars may be obtained by United Kingdom firms on application to the Enquiry Room, of the Department of Overseas Trade, 35, Old Queen Street, Westminster, S.W.1.

# The Question of Electric-Furnace Linings.

By F. W. BROOKE.

Most of the electric furnaces working in Great Britain are basic lined, but for steel castings, acid-lined furnaces are successfully employed, and the following article has been written with a view to helping interested persons to make a decision as to which is the more economical to work.

Acid operation should be adopted when:—

1. The sulphur in the scrap is and always will be less than the sulphur specified for any castings likely to be required.

2. The phosphorus in the scrap is and always will be less for the phosphorus specified for any castings likely to be required.

3. When the range of carbon and silicon contents will always be wide.

4. When close physical tests have not to be met.

5. When power consumption and rate of operation are of prime importance.

6. When very small castings are the sole output.

Basic operation should be adopted when:—

1. The sulphur in the scrap now or in future may go above the limits required for chemical or physical tests or requirements.

2. The phosphorus in the scrap now or in future may go above the limits required for chemical or physical tests or requirements.

3. When the steel has to be made (for chemical or physical reasons) to a close carbon, silicon or manganese analysis.

4. When close or good physical tests have to be met.

5. When alloy steels are ever to be made in the furnace.

6. When steady load is essential.

7. When refining of cast iron is being considered.

A manager of an electric furnace, in looking over his available scrap supply, often feels he can obtain all the scrap he requires of a sulphur and phosphorus content low enough (say, below 0.04 per cent. sulphur and phosphorus) to meet his requirements. The scrap market only too often upsets his calculation, and he is confronted with the problem of having a high sulphur and phosphorus scrap and a furnace which cannot eliminate these all-important injurious elements. It has often meant one of three things: paying an excessive price for low sulphur and phosphorus scrap, a shut-down until proper scrap can be obtained, or bad castings and a dissatisfied customer.

Let us assume that the above situation can be satisfactorily met. There is still the subject of requiring a low sulphur for special occasions, as, for instance, the making of a specially difficult casting where the foundry has its own particular difficulties, and where a low-sulphur steel would be of particular value in helping out the foundry. This can only be done in basic furnace.

It is much easier to control the carbon, silicon and manganese in the basic furnace, which means that where specifications have to be met, the rejections are much less, particularly on physical tests, such as good relation between the maximum stress and yield point, and a good elongation with a relatively high maximum stress. This is because of the inherent value of an electric furnace for making refined steels of a quality better than the converter steel, the open-hearth steel and at least equal to crucible quality, which is only present in the basic operation.

Refining can be done in the acid furnace to a limited extent, but calls for skilful operation, and is not reliable.

The acid operation gives a better power consumption in the relation of about 100 to 112, because there is practically no refining in the acid operation. It also gives a lower refractory cost, as the cost of raw material is less and the repairs are less frequent.

If alloy steels are ever contemplated, basic furnace is required. Manganese steels, for instance, so often required in the steel foundry industry, can only be economically made in the basic furnace. The use of other elements, particularly chromium, vanadium, etc., can only be handled in the basic furnace, and while the making of alloy steel castings may not be of immediate consideration, their use is becoming more general every day, especially for parts requiring uniform wearing qualities, resistance to shock and resistance to alternating stresses.

A basic furnace invariably has a steadier load than in acid furnace, for two reasons: Higher secondary voltages are used in the acid to bring about more rapid melting. The resistance of an acid slag is higher than the resistance of a basic slag, and therefore also requires a higher voltage.

Both of these calling for a higher secondary voltage cause in practice longer arcs and higher surges, because the electrode travel cannot be adjusted so rapidly.

In making all small steel castings, three important points must be kept in view:—

(*a*) The furnace must not be of too large a capacity, several smaller units give better satisfaction; for instance, when the castings do not exceed 10 to 15 lbs. a 1-ton furnace should be the maximum.

(*b*) "Hot" metal is essential, because of the necessity of pouring into shank ladles where the transfer losses and the ladle losses are high, and because of the number of "pours" required.

(*c*) It must be easy to hold back the slag, and acid slag will keep back and separate more readily than basic slag.

This does not mean that small castings cannot be made in the basic furnace, but means that in foundries where castings weighing ounces and a maximum of, say, 25 lbs. are to be made, the acid operation is easier and more economical, providing, of course, that the other clauses can be met satisfactorily.

Probably the latest field which is making rapid strides for the electric furnace in the foundry is for the refining of cast iron. This is particularly applicable to the making of engine cylinders, high-pressure valves, piston rings, and parts requiring uniform wearing qualities, etc., and the practice now being adopted is to pass the molten pig-iron from the cupola through the electric furnace for a refining period of 20 to 40 minutes, which gives a rapid desulphurisation, associated with the elimination of occluded gases, and an accurate pouring temperature.

These causes will speak for themselves to the progressive foundryman, who in the past on particular work has passed through periods of worry in this, through sulphur in the coke, blowholes, and "hot" and "cold" metal.

Only the basic furnace can be considered for this purpose.

In looking over the number of furnaces recently installed in American foundries, it is surprising to find the large percentage of acid installations. This should not be taken as a criterion. These furnaces were only too often installed by foundries that used electricity as a "fuel" and the electric furnace as the melting pot, thereby hurting the electric steel field. They sold their product during a time when the sulphur and phosphorus specifications were eased off and physical requirements were seldom met. This does not mean that the acid furnace has not its own field, but its installation should only be decided upon after a careful study of all the existing and future conditions.

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**EFFECTS OF COOLING ON THE MAGNETIC PROPERTIES OF STEEL.**—In a Paper on the "Effect of the rate of Cooling on the Magnetic and Other Properties of an Annealed Eutectoid Carbon Steel," issued by the U.S. Bureau of Standards, Messrs. C. Nusbaum and W. L. Cheney describe how six specimens of eutectoid carbon steel were selected, heated to 800 deg. C., and allowed to cool at various rates. One was cooled in air, another in lime, and the others in the furnace at slower and slower rates. Observations were then made to determine the magnetic and other properties. The experimental results show:—(1) With a decrease in the cooling rate there is a marked increase in the value of the maximum induction for a given value of the magnetising force, an increase in the maximum permeability, and a decrease in the coercive force. (2) As the structure is changed from an essentially sorbitic one to "divorced" pearlite, there is a gradual shifting toward the origin of the break in the reductivity line and an increase in the difference between the "real" and "apparent" values of the maximum intensity of magnetisation. (3) There is a good agreement between the values of the coercive force and the scleroscope hardness as influenced by the various cooling rates.

# Open-Hearth Iron.

In a Paper entitled "The Development of Commercially Pure Iron in the Basic Open-Hearth Furnace," and read before the American Iron and Steel Institute, at New York, MR. W. J. BECK, Director of Research, American Rolling Mill Company, Middletown, Ohio (U.S.A.), remarked that there has always existed a demand for the purest obtainable irons. This demand has held steadfastly in the face of rapidly developing steel-producing processes. The steady importation of Swedish iron up to the outbreak of the war in 1914 is sufficiently indicative of this fact. These foreign irons, however, that had to be laboriously worked down by a charcoal or puddling process, were not suited to the large-scale tonnage operations which are made imperative by American conditions of labour and industry. It is natural, therefore, that metallurgists should have been led to the consideration of adapting the open-hearth furnace to the manufacture of iron of at least an equal degree of purity as the types imported from overseas. Every open-hearth man, however, knows what is implied in raising the temperature of a bath 200 deg. above the normal practice and maintaining this temperature until the carbon and manganese are run down to practical traces.

Ingot iron made in an open-hearth furnace differs from the older irons in having a typical crystalline structure, a more definite critical temperature range, and more particularly in being essentially free from slag. In the first heat an attempt was made by the American Rolling Mill Company to produce a metal containing not over 0.05 per cent. manganese. It was done at the risk of losing the heat and the ladle, but it was felt that such a drastic step was necessary in order to determine if it were possible to make such a product in an open-hearth furnace. Care was used in the selection of the raw materials for this heat, so that the melt would be as low as possible in carbon and manganese. The heat was charged in a 35-ton furnace and the bath of metal melted low in carbon, as it was believed that the lower the carbon could be driven the lower would be the manganese. Regular open-hearth practice was followed with the exception that an additional quantity of iron ore was added to assist in the removal of the carbon and manganese. In addition to this an excess amount of lime was charged for the purpose of eliminating as much sulphur and phosphorus as possible. These early experiments in the open-hearth furnace were made with producer gas as fuel. This fuel was high in sulphur which contaminated the metal and presented a serious obstacle. It was later found that by the use of natural gas this difficulty was largely overcome and it was possible to produce a metal which contained a lower percentage of sulphur.

In order to eliminate as far as possible the impurities in these heats it was found necessary to hold the metal in the furnace longer than is required in ordinary steel practice. In some cases these experimental heats were held in the furnace as much as 50 per cent. longer than the ordinary steel heat, with danger to the operators and to the furnace. On tapping the first iron heat into the ladle it was "wild." The normal amount of aluminium customary in making steel heats had been used, but in later developments it was found necessary to increase materially the dose to insure proper deoxidation and degasification. In the early development of this iron it was made on a small-plant basis, using bottom-pour ingots of about 8 in. x 10 in. cross section, and weighing about 900 lbs. In this bottom-pour practice it was necessary to line with fire-clay runner brick the runners which conducted the metal to the ingot moulds.

When pouring the first heat, the metal was so hot that the stopper rod burnt off and there was much difficulty in pouring the metal, the moulds were smeared, and much of the metal was lost by pouring into the mould pits. Considerable cutting of the runner and ladle lining also occurred. The ingots were stripped in the usual manner and sent to the reheating furnace, where they were rolled into heavy-gauge sheet bars without difficulty, and later into 16-gauge sheets and sheared to size for galvanising. Considerable difficulty was found in pickling the sheets on account of the slow solubility of the metal, and also on account of the presence of foreign matter such as fire-clay from the runner brick and ladle linings. In galvanising the sheets, further difficulty was encountered in the development of blisters and rough surfaces, which were afterwards found to be due to imperfect degasification of the metal.

The analysis of this first heat of ingot iron was: Si trace, S 0.028, P 0.003, C 0.03, Mn 0.04. At that time it was customary to analyse only for these five elements, the aggregate of these being subtracted from one hundred, which was the basis then used, indicating the iron content by difference.

In the manufacture of such pure metal the process of degasification was at the outset not understood. A large number of sheets were produced which contained imprisoned gases. When such sheets were galvanised the expansion of the imprisoned gases caused the formation of blisters up to 12 in. in diameter, giving a product which could not be sold even as wasters, and of doubtful value as scrap. This resulted in a further search for a method to eliminate the gases responsible for the blisters. Green saplings were plunged into the metal bath in the open-hearth furnace after the heat was melted, in an effort to agitate the metal to help to remove the impurities. This slightly reduced the time of finishing the heat, but nothing could be found to substitute for the extremely high temperatures necessary to reach the desired analysis of the metal.

The high temperatures shortened the life of the furnaces and greatly increased the cost of the iron. In fact, it was impossible to produce continuously in the furnace because of the cutting action on the linings due to the high iron-oxide in the slag. To meet this contingency heats of pure iron were alternated with regular steel heats. The experimental heats of iron produced many unusual and unlooked-for results. One of the heats contained so much gas that nothing but piped ingots were made. In fact, some ingots were piped from end to end with only a thin wall. These had the shape of the moulds and weighed but a few pounds, whereas they should have weighed about 900 lbs.

Special efforts to secure iron of extreme purity were continued in the open-hearth department during 1906 and 1907. Every effort was made to produce a material of high purity. Many suggestions were tried. As the experimental work progressed it was found that there were considerable differences in the practice of producing commercially pure iron as compared with steel practice, which materially added to the cost. In the first place, it required several hours longer to make an iron heat than a steel heat, and the final temperature of the metal was 200 deg. Fah. higher than a heat of steel. Another marked difference was also found between the percentage yield of iron as compared with the yield when steel was made. The percentage of metal produced was several per cent. lower in the iron heats because the high temperatures and longer time employed in the manufacture of iron, oxidised more of the iron, which was lost in the slag. It was also found that the high iron-oxide content of the slag was responsible for the cutting action on the stopper rods and bricks and that the scorifying action increased as the percentage of iron oxide in the slag increased.

Early ingots were frequently split with a metal saw so that the interior structure and the degree of degasification could be studied. It was found that ingots degasified with a slight excess of either silicon, aluminium or even with the use of a small amount of ferro-manganese, may be perfectly sound as far as gas pockets are concerned. Nevertheless, such material will go to pieces when an attempt is made to roll it. This breaking up of material degasified with an excess of degasifying agents led to the discovery of the fact that pure iron had to be worked within a certain range of temperature; otherwise, it was found to be red-short and could not be rolled. It was also found that not only was the rolling of commercially pure iron affected by the presence of impurities from the degasifying

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agents, but also by the presence of sulphur. Being almost pure, this iron has, like many commercially pure metals, a critical range at which temperature it cannot be worked. This temperature is about 900 deg. C., but for working conditions it is impracticable to roll at temperatures between 800 and 1,000 deg. C. In the commercial manufacture of such pure iron it is necessary to roll the material above the critical range on the blooming mill and below the critical range on the bar mill, which necessitates cooling tables unnecessary in steel practice between the two mills. This delays rolling and adds materially to the cost of iron. Because of the tendency of the sheets to weld together at the higher temperatures, the sheet bars also must be rolled on the sheet mills at much lower temperatures than employed in rolling steel sheet bars.

The use of the microscope plays an important part in the final treatment of these commercially pure iron sheets, and special care is necessary in the annealing of the sheets in order that they may serve the purpose for which they are intended.

Having developed an open-hearth iron primarily for its rust-resisting properties, it was found upon further study that it had many other interesting and valuable qualities, which, taken together, made a metal for more general use than had been attained by any other ferrous sheet metal product. The high purity of the metal finally attained is shown by the following average analysis: Si trace, S 0.035, P 0.005, C 0.013, Mn 0.021.

It was found that this pure iron galvanised in a superior manner to steel. Exhaustive tests have shown that when various grades of steel are galvanised in the same pot and under exactly the same conditions as when galvanising this pure iron, not only will the pure iron take on a heavier coating, but this coating will have less tendency to peel when the metal is fabricated. Pure iron goes into solution in molten spelter more slowly than steel; and pure-iron flux boxes and gears which are immersed in molten spelter will outlast many times similar equipment made from steel. It has been determined by analysis that the iron content taken up by the spelter on steel will average much higher than the iron content of the spelter on pure iron.

For twelve years the metal has been tested under a great many laboratory and service conditions, and the results obtained indicate that it is suitable for many exacting needs where ordinary steel has not proved satisfactory. The purity of this product and the careful methods used in its manufacture make it more homogeneous than steel, and it therefore flows uniformly when heated to a melting temperature. This characteristic led to its use for many purposes where the cost or efficiency of welded articles depended upon quality of the weld or ease of welding operations. The welding quality of commercially pure iron created a demand for this material in the form of welding wire and rods to such an extent that conversion arrangements were made for the manufacture of large quantities of commercially pure iron welding rods and wire. This material has already largely displaced the welding materials of foreign manufacture previously used in the United States.

The average analysis compiled from records covering a period of twelve months gives this iron a purity of 99.865 per cent. This takes into consideration the nine impurities—silicon, sulphur, phosphorus, carbon, manganese, copper, oxygen, hydrogen and nitrogen.

## Deaths.

MR. J. T. SIMPSON, of South View, Thornley, chief mechanical engineer to the Weardale Steel, Coal and Coke Company, Limited, died on June 19, following a road accident.

MR. G. STEVENSON has died at the Manor House, Eckington, Derbyshire, in his eightieth year. He was a director of William Cooke & Company, Limited, Sheffield, and J. & G. Wells, Limited, Eckington.

MAJOR J. COOK, of North Biddick Hall, Washington, who died on June 13, was chairman of the firm of Joseph Cook, Sons & Company, Limited, steel and iron founders, Washington, and took a great interest in local affairs in the Washington district, where he was highly respected.

## Madagascar Graphite Industry.

According to a published statement of the Chief of Madagascar Service of Mines, based upon an investigation made by the local Government, the quantity of graphite in stock in Madagascar on April 1, 1920, amounted to 32,000 tons. At the end of 1920 24,000 to 25,000 tons were estimated to be in stock. No precise data are available as to the quantity of the different grades of graphite on hand, but approximately nine-tenths of the stock is flake graphite, the remaining being amorphous. Three-fourths of the flake graphite averages 80 to 90 per cent. carbon, particularly of the old stock, the tendency now being to turn out an average quality of 90 per cent. and above, because of the restricted demand.

Of the graphite shipments in 1920 a total of 4,449 tons went to England, 2,127 tons to the United States, and the remainder to France, with the exception of 51 tons shipped to Belgium. Shipments have again been reduced, and the only information to be had concerning the present demand is regarding a contract held by one of the large mining concerns for 2,000 tons, to be delivered in the present year to France.

The prices obtained for the graphite shipped in 1920 averaged 600 to 700 fcs. per ton, f.o.b. Tamatave and Vatomandry, for material averaging 85 to 90 per cent. carbon, prices at which quantities of Madagascar flake may now be obtained.

It is estimated that about 20 per cent. of the total production of Madagascar graphite is treated mechanically. There are perhaps not more than half a dozen plants equipped with machinery, which consists chiefly of drying, separating, classifying, ventilating, and screening devices, kept more or less secret.

## Gazette.

A WINDING-UP order has been made against the United Engineering Company, Limited, 22, Basinghall Street, E.C.

THE FORTH SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, are being voluntarily wound up, with Sir Edmond Browne, 2, Pump Court, Temple, London, E.C., as liquidator.

THE names of the undermentioned companies have been struck off the Register of Joint Stock Companies, and such companies are dissolved:—Bradley Tool Manufacturing Company, Limited; British Silica and Minerals, Limited; Champion Engineering Company, Limited; Cornish Wolfram Mines, Limited; Crompton & Hauman Engineering Company, Limited; Deep-Water Engineering Company, Limited; Docks & General Construction Company, Limited; Draycott Boilers, Limited; Draycott Engineering Company, Limited; Greensmith Alloys, Limited; Hardware & Engineering Supplies Company, Limited; Hydrolio Furnace Company, Limited; Intaglio Depositing and General Engineering Company, Limited; J. G. M. Machinery Company, Limited; Kaywright Engineering Company, Limited; Light Forgings, Limited; Monolith Wagons, Limited; Ores & Mineral Finance Syndicate, Limited; Rossol Engine Syndicate, Limited; Sheet Metal Workers Company, Limited; Sheffield Ball Bearings Company, Limited; Small Tool Supply Company, Limited; Snyder Electric Furnace Company, Limited; Strong Steel and Chemicals, Limited; Victoria Metal & Engineering Company, Limited; Western Metal Works, Birmingham, Limited.

**HAUTS FOURNEAUX DE PONT A MOUSSON.**—This company, which has a world-wide reputation for cast-iron pipes, is just putting into operation a small foundry entirely devoted to small machine-moulded castings. This new department is a portion of the foundry reconstruction programme, as their buildings were almost completely destroyed. The whole installation will be modern in every respect, being provided with electric overhead travellers and mono-rails. Five cupolas are to be employed, and are expected to produce 1,000 tons per month. The pipe foundry is already making about 2,500 tons monthly, and roughly two-thirds of the works are now in operation. The brick-making plant is now working regularly, but the cement works are still unoccupied. Lime kilns are being erected and a coke-oven plant is under consideration.

# The Design and Equipment of an Iron Foundry.—Part II.

By Joseph Horner.

*Moulding Methods.*—The preparation of moulds affords by far the largest scope for effecting economies in any foundry. These include preparation by hand simply, by turning over in the overwhelmingly largest volume of work done, by bedding in, in a moderate proportion only, and loam in a varying amount. Applicable to the first only are the methods associated with the mounting of patterns on plates for hand- or machine-moulding.

Hand-moulding by turning over is a method wasteful of time, which handicaps foundries in the competition of prices. A dummy box of sand is thrown away for each mould, and the joint face has to be formed afresh, whether it is of plain or irregular shape; and the runners, even if numerous, have to be cut afresh in each mould. What waste of time this entails when repeated on every mould made in a large foundry is appalling. In the general shop there are many jobs which do not admit of the practice of economies that can be effected when work is sufficiently repetitive to permit of mounting patterns on plates. But half-way methods are available. When there is a considerable proportion of heavy castings not called for in large numbers these are necessarily moulded by hand. But help is afforded by the employment of bottom or turn-over boards, stocked in various sizes, the use of which avoids the wasting a box of sand for bedding the pattern into, and providing a sand joint with the trowel. If castings, even though large, are repeated at frequent intervals, a further economy is practicable by mounting them permanently on their own joint boards. If the patterns are divided the halves or portions can be put on opposite sides of the same board, so plating them, and runner patterns can be attached to the board. These are the last economies available in hand-made moulds.

In the smaller moulds, and those of moderate dimensions, say, not exceeding from 3 ft. to 4 ft. in length or diameter, and usually repeated day after day, the economies afforded by plating are very great. Both joint plates and patterns may be of wood or metal. They can be moulded by hand in flasks to which the plates are fitted, or mounted on a machine table. Employing the latter, there is the further advantage either of mechanical sand pressing in place of hand ramming, or of mechanical delivery, or of both, depending on the design of machine used. In any case, other labour-saving economies are possible, such as the mounting of a large number of small patterns on one plate and all suitably gated. If the patterns are such that the mould requires irregular joint faces, curved and sloping, these, which occupy much time in shaping by hand, are produced once for all on the faces of the plate, usually by casting the patterns integral with their plate. And again, two portions of a divided pattern may be mounted each on its own separate plate, to be moulded by different men, or side by side on one machine table.

The output of moulds from plated patterns is large, and they must occupy a floor area apart from that of the general hand work. It is well to have this adjacent to the machine-moulding department, since they require similar services. In the plan arrangement given these occupy a length of 40 ft. and a width of 70 ft., being spread over two bays. A bench is used for small plate moulding. Some machines are located in the fellow bay: spaces are occupied with sand-bins and flask piles, and a small room is used as a store for patterns, but many are conveniently hung on the wall. If the floor area is unsufficient for heavy casts, a portion of the unappropriated space adjoining the time office can be occupied. When machine work increases, the hand plate moulding can be transferred to a section of the long bay devoted to light castings. Very much machine moulding, using iron patterns, requires crane service. This work is covered by the overhead travelling cranes. Hand-plate moulding is generally limited to the weight a man can lift without undue fatigue, boxes of 18-in. to 24-in. square or round being the limit, but depending partly on the way the pattern is made and on the depths of flasks. Patterns and plates of wood are used, but metal plates of, say, $\frac{3}{4}$ in. thick are preferable, and in many cases metal patterns can be lightened by casting them as mere shells, $\frac{1}{4}$ in. or $\frac{3}{8}$ in. thick.

By an inevitable sequence the question soon arises concerning the desirability of the transference of plated patterns to machines, but the selection of the best type of machine is not easily determined. In a good many designs hand ramming is necessary, in others the sand is squeezed with a presser head. In each the delivery may be by hand, or with mechanism that provides a precise vertical withdrawal. In the greater number of designs and in all the heavy types the two functions are combined. Almost all designs are built in a good range of dimensions, and with varying useful details in the methods of operation. The excellent designs are so numerous that it is not possible to name even the machines of established reputation. It is better here to deal with the leading practical aspects of moulding machines from the point of view of their general utilities and applications.

Patterns for machine moulding are fastened directly on the table of the machine, or they are attached to it through intermediate plates. Many machines offer the double advantage that their tables may receive patterns of wood from which only a very few castings are required, or those of metal attached permanently to their metal plates, or patterns of metal can be secured without intermediate plates for a product that is highly repetitive. The next aspect is that in which a distinction is made in the designs of the tables themselves. These are either of the rigid, or of the turn-over design or of the rock-over type, each of which is embodied in large groups of machines. In each, also, the ramming is either done by hand or with a presser head, and the delivery is by a hand lift or through mechanical guides. In all, with few exceptions, the sand is rammed over the top of the pattern only, the chief exceptions being in that relatively small group in which both sides are pressed simultaneously. While as a general rule, delivery is effected by the lowering of the moulding box away from the pattern, as on turn-over table machines, the pattern is withdrawn in others, or the box is lifted off it on "stools," or vertical rods, in machines with fixed tables. In snap flask work there is no lifting or lowering away, but the pattern or pattern section is withdrawn by hand and the box part is simply opened out laterally on its hinge, leaving the mould standing on the bench ready for removal to the casting floor.

With reference to the selection of machines with fixed or with turn-over tables, the latter should generally have preference, because both sides can be utilised at the same time, one for the cope, the other for the drag of the same mould, the box pins going through the table. Another fact in favour of this is that the mould, carried on a table below, is lowered away from the pattern, which is preferable to lifting the mould off it on stools brought up through the table from beneath. But, obviously, while either method may be selected as suitable for shallow patterns, it is necessary, with patterns having deep perpendicular sides and box parts carrying large masses of sand, to draw the mould away from below, or, as in the large group of rock-over machines, to lift the pattern out of the mould as in hand work. If a deep mould is lifted on stools off a pattern there is much risk of a drop-out occurring, favoured by the fact that the table is rapped with a mallet during delivery to assist the detachment of the sand from the pattern.

But there is another point of view. When very large volumes of repetition work are being done the advantages offered by the turn-over table diminish,

and, therefore, many of the larger machines have a rigid table, and the top and bottom box parts are both rammed at the same time side by side, or a number of drags first, followed by an equal number of copes, or they are prepared on separate machines. Again, all patterns with deep vertical sides have to be withdrawn through stripping plates, and these require a rigid table, the pattern being pulled downwards through the table, which is an open frame in this case, slotted to encircle the pattern, or only those portions of it, as flanges that must be stripped. If a turn-over table machine is used, the stripping plate must be prepared as a part of the pattern equipment, which entails expense and leads into a field of pattern construction where often the parts differ in several details from those which are prepared for ordinary moulding, being made in sections to suit the machine methods adopted. Then there are the growing numbers of machines specially designed or adapted for working double-sided for multiple moulds, poured in piles, for the making of small belt pulleys, trolley wheels, light frames—all shallow and of simple forms. From this wealth of mechanisms a firm must select the type or types that are best adapted for their product, ranging from those suitable for the attachment of ordinary patterns and those which are plated, to the shapes that, being made in large numbers, require the aid of specialised machines. But, apart from this, the question of operation by hand or by power soon arises.

*Hand v. Power Operation of Machines.*—Hand-worked moulding machines, even when of large dimensions, give good results. The labour of turning over tables, of withdrawing patterns, or lifting moulds is lessened by the inclusion of gears, counterweights, and springs so efficiently that many very large machines are actuated with levers or hand wheels. Yet power is desirable in heavy moulds, but it has to be installed. It is either compressed air or water, and in a small degree electricity. Compressed air is, on the whole, the most suitable, and the air hose-pipe is useful in place of the bellows for blowing loose sand out of moulds and off machine tables and patterns, and for the vibrators which take the place of hand-rapping in machine moulding. This power agency is the one almost exclusively employed in many recent designs of rock-over machines and in the most important recent development—that of the jar-ramming or bumping machines, in which compressed air is used to lift the table. Hydraulic pressure is not regarded with favour in England or America, while common on the Continent, where very massive machines, some highly specialised to deal only with a single product, are installed. These are commonly provided with tracks for bringing along the boxes and removing the moulds.

When there is a regular output of castings, heavy or of moderate dimensions, and of fair depth, jar-ramming machines show to best advantage. The deeper the moulds the better, since the sand is consolidated more closely in the lower parts than in the upper strata. For shallow moulds the machines are not suitable; in fact, plain shallow tops are often hand-rammed or squeezed elsewhere, though the deep bottom moulds are jar-rammed.

Large cores can be made on ordinary moulding machines by hand-ramming and pressing. The boxes are prepared specially, being chamfered around the core outlines to permit of the surplus sand getting out of the joint faces. The amount of sand required is measured as nearly as possible with an encircling sand frame of wood, set over the lower half-box, a similar device to that adopted when making pressed moulds. Small round cores are economically compressed in the Wadsworth machines. Small cores—round, square, polygonal—required in large numbers, are best made in special machines fitted with vertical tubes, within which the cores are rammed by hand to any lengths required within the capacity of the machine, and from which they are ejected with pistons, there being one or more tubes mounted, and often interchangeable for cores of different sizes and sections, each with its piston.

*The Work of the Cupola.*—On the operation of these, with due regard to economy of coke, and the condition of the iron run down, the results achieved in a foundry largely depend. Though the lay-out for the work done may be good, and moulds be produced at a minimum cost, yet the melting of metal may be extravagant and its quality poor, or its grade be unsuitable, with a resulting excessive proportion of wasters. It is not necessary here to discuss the numerous details of construction and the advantages claimed for different designs. Many were bad in years gone by, but excellent types predominate now in consequence of the better understanding of the conditions of economical melting that is diffused. At the present time almost everything in the way of results depends more on the method of operation than on the distinctive design.

It will be sufficient if the observations to follow relate to one of the ordinary English cupolas used in immense numbers. It has a tall shaft, an air belt enclosing either one or two rows of tuyeres distributed equally round, the upper and lower rows being arranged to hit and miss. It may have a reduced section in the tuyere area—the bosh form—to lessen the travel of the blast, and reduce the bed charge. It is well to have a receiver, in which the metal collects as it melts and remains hot and away from the oxidation of the atmosphere until wanted, being preferable to allowing two or three separate tappings to stand in an open ladle. Either a blower or a fan is suitable if run at proper pressure and volume, but the former grows in favour.

The economy of the melting ratio must always be regarded in relation to the character of the work being done. From 2 to 3 cwt. of coke used per ton of iron melted is good average practice. Anything below 2 cwt. is very exceptional, and is only possible in prolonged casts with a deep bed charge, using the best coke, good iron, suitable blast supply, judicious proportioning of fuel and iron, and metal melted in large quantities. There is also the important difference in the condition of the iron when tapped, whether it is imperfectly or dead-melted.

The art of melting consists primarily in directing volumes of blast, the pressures of which may vary with the loose or dense character of the charges, to utilise all the heat units possible by the combustion of the coke. Two oxides of carbon are produced in the cupola, and economy of working depends on their combustion. Carbonic oxide, CO, is combustible, provided it is brought into contact with free oxygen. Carbonic anhydride, $CO_2$, does not burn, but taking up more carbon becomes $C_2O_2=CO$, rendering it combustible. But if CO does not meet with a sufficient volume of heated oxygen it will not burn, but its heat units will be lost. If carbon is only burned to CO each lb. develops but 4,415 B.Th.U., but if it is perfectly consumed to $CO_2$ it evolves 14,647 B.Th.U. With an insufficient air supply, or one improperly directed, the first oxide is formed, with a loss of about two-thirds of the heat units possible. These are theoretical values only, which are never possible of translation into practice, due to heat losses in warming the incoming blast, in heating the inert nitrogen, in heat discharged from the top of the cupola, etc., so that only one-seventh or eighth of the theoretical values can be secured, but the relative values of combustion of the two oxides remain unaffected.

Present-day cupolas owe their efficiency, first to the fact that they are tall by comparison with their predecessors, which, by delaying the premature escape of CO, brings it into contact with heated oxygen, evolving $CO_2$. In low cupolas much of the CO burns at the charging door, as evidenced by the rush of flame there. In the second place, efficiency depends on the supply of additional oxygen through the upper row of tuyeres, which are usually of smaller area than those in the lower row. But of equal importance is the equable distribution of the blast, with its diffusion to the centre, with lessening risks of chilling, or of local cutting; keeping the openings clear of slag, and varying the volumes and pressures, as the melting proceeds. Ultimately, therefore, the furnaceman is mainly responsible for results. If careful, he varies the blast pressure to suit the melting. It also varies automatically from the time the blast is put on to the running down of the metal, because the liquid metal and slag offer increased resistance to its diffusion. A blast gauge is desirable, usually graduated in ounces, and reading to 2 lbs. Roughly, 12

ozs. is an average pressure per sq. in. Regulation of pressure is provided by a blast gate. In some cupolas the amount of opening of the upper row of tuyeres can be altered, and they can be entirely closed. The more uniform the work of a cupola is in regard to the character of the iron melted from day to day the less anxious is the work of the furnaceman. The possession of a cupola of high repute does not relieve him from the necessity of constant observation of the way in which the melting is proceeding.

Blast is supplied either from a fan or a blower. The efficiency of the latter is higher than that of the former, and there is less difficulty in regulating pressure and volume. The fan is satisfactory for pressures up to, say, 8 ozs. per sq. in.; the blower is better for those which are higher, which may, in the larger cupolas, range from 12 to 16 ozs. A fan is cheaper; it requires less solid foundations, and its repairs may cost less. If selected, it must be of ample diameter, since the power to drive varies as the cube of the speed. Doubling the speed doubles the volume of air delivered, but the power is increased eight times. Of much importance is the transmission. Pipes must be of ample diameter, with large easy bends, and the distance from blower or fan to the cupola must be short or there will be a great drop in pressure.

It is almost essential to have two cupolas of larger and smaller capacities in the average foundry, because the quantity of metal required for a day's cast varies greatly. Large moulds may take some days in preparation, and have to be poured all on the same day, so that the larger cupola may be requisitioned, or both at the same time. It is also necessary at long intervals to repair the firebrick lining. An entire cast of special metal may engage one of the cupolas. But in the ordinary way different grades of metal are being melted at the same time in upper and lower strata, with a charge of coke separating them. The upper layers being above the melting zone, which is confined to the vicinity immediately above the tuyeres, will not become liquid until the lower is at the tapping hole. When a small product of a special mixture is required the little emergency cupola is used.

Since it is desirable to locate the cupolas in one house, close to the blast supply, the metal is transported on carriage ladles across the bays, to be picked up with the cranes, or directed along the tracks, the arrangement being shown in the plan view. Small hand and shank ladles can be supplied from these. Large ladles of metal for the bay adjacent to the cupolas are picked up by the overhead cranes. The ladles are stored adjacent to the cupola house alongside the wall. The ladles, like the furnaces, have to be lined with fireclay every morning.

*The Brass Melting Furnaces.*—Three of these are indicated in Fig. 1. As it is assumed that the brass foundry is a relatively small department, the ordinary coke-fired furnaces built of brick, lined with firebrick, each holding one crucible, lifted out with tongs by hand are suitable. Frequently only one furnace is in use at a time. The others are a stand-by for heavier casts, or may be idle for repairs. The draught is that of a chimney 18 or 20 ft. high, common to all. Cinders are cleared out through a pit in front. These, of course, are not the most economical type when large quantities of brass have to be melted, not even for coke-firing. They could not be considered now for the regular foundries that handle a large output. Many coke furnaces are heated with blast. Many have a preheating chamber, where the lumps of metal are warmed by the waste heat from below before it is dropped into the crucible. Furnaces are made to tilt, so that the metal is poured from the spout of the crucible without removing it, by which means some loss of heat which occurs when the crucible is lifted out is avoided, the caster works more comfortably, and crucibles of much larger capacity than those which are lifted out with tongs can be used. Oil fuel is used with great advantage, working at low or high pressures—almost any oil being suitable. Little waste of fuel occurs for heating up, as with coke, and there is no surplus to burn out after melting. The temperature can be regulated, and there are no ashes to be removed.

Electrically-heated furnaces are used rather extensively now, but only or chiefly in foundries where very large quantities of metal are being melted. The advantages are great, the principal one being that the melting is done in a closed furnace, in a non-oxidising atmosphere, so that there is very little loss of the zinc in brasses, and as a result the grading of all the brass and bronze alloys can be done with a greater approach to precision than is possible in the solid fuel furnaces. The electric energy is utilised in one of two ways in different designs. In the arc furnaces the heat is generated in an electric arc formed between two electrodes, and the heat is transmitted to the metal below, partly by conduction, partly by radiation. Or the arc may be formed between one electrode, and metal or slag. In the resistance furnace the action is that of the incandescent lamp, the current passing through the liquid metal, or slag, and becoming heated sufficiently to produce fusion.

Before leaving this subject brief mention should be made of three matters, attention to which is usually more honoured in the breach than in the observance. Firstly, with regard to power. It will have been noticed that the scheme outlined provides for electric driving throughout, from one power house having a dynamo set of sufficient capacity to supply all the motors for the overhead travellers, and the jib cranes, leads to which are carried along the shop girders, and the motors for the machines in the fettling, and the grinding rooms, for an air compressor, if installed, and for artificial lighting. The horse-power installed need not total to the aggregate of the whole of these demands, since all the cranes, machines, etc., will never be in operation at the same time, or making maximum demands on the current. From one-half to two-thirds of full requirements is ample, and considerable overloads can be imposed without excessive overheating.

The only artificial lighting suitable for a foundry is that of arc lamps. At a height of 20 ft. or more they give a powerful diffused illumination, without dark shadows. The question arises of the additional help needed when cleaning the interiors of moulds, and setting cores. Filament lamps may be used for this work, but it seems more convenient to employ as of old the hand oil lamps, or candles, for the purpose.

The ventilation and heating of a foundry cannot be ignored when altruistic views are being taken. In winter time a shop, the doors of which are being opened perpetually, is very cold until the afternoon, when the metal is being poured. Then, and also from coke fires, sulphur fumes hang about. In summer time the building becomes hot by the transmission of heat from roof and walls. To make a shop quite comfortable a system of ventilation and heating should be combined. The plenum or pressure system is to be preferred, in which the air is forced by a fan through a stand of pipes, the heater, warmed with steam, and distributed and discharged through suitable pipes into the building. The pipes are carried along high up by the columns, and the discharges take place downwards without interfering with the workers on the floor.

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**AMALGAMATION OF FRENCH FOUNDRYMEN'S ASSOCIATIONS.**—At a recent meeting of the French Ironfounders' Association it was decided to amalgamate with the Steel, Malleable, Aluminium, Copper and Bronze Founders' Associations, under the title of Le Syndicat Général des Fondeurs. Each Branch will retain its own president, who will be a vice-president of the parent Association.

**AN ELECTRIC ANNEALING FURNACE.**—The Electric Furnace Construction Company of Philadelphia, the American house of Messrs. T. H. Watson & Company (of Sheffield), Limited, has secured an order from the Sociedad Española de Construccion Naval, Spain, for a new design of electrically-heated car-type annealing furnace for heat treatment of large steel ingots and forgings. This furnace will be approximately 22 ft. long by 15 ft. wide by 13 ft. high. It will heat a charge of 60 tons of steel to 925 deg. C. An electrically-heated furnace by the same makers, 36 ft. deep by 12 ft. outside diameter, for the heat treatment of gun and large forgings, is already in operation in Spain. The heat regulation is claimed as the outstanding feature of these plants.

XUM

# Some Notes on Case Hardening.

By Christian Kluytmans.

Future competition in the automobile industry emphasises the necessity of using first-class raw material in order to enable the manufacturer to compete against and perhaps have an advantage over other competitors.

The necessity of exercising strict scientific control over all raw material is thus made imperative. The manufacturer uses this raw material either as received, or with one of the following alterations:—(1) Raw material altered by fusion, such as castings; (2) raw material altered by heat treatment.

These are most important from the point of view of the motor car manufacturer, as they have to be altered in his works, under the supervision and responsibility of the metallurgical chemist. Raw material used as received is also under the supervision of the chemist, but the supplier should be responsible for the quality of the material. In both cases the raw material will be verified to ensure that it has been delivered by the supplier in conformation with the specification, or that the quality is up to standard. To effect this, it is necessary to have a competent man in charge of such scientific control; the metallurgical chemist, with his theoretical and practical knowledge, is most particularly suited to this purpose.

Besides having theoretical knowledge, the metallurgical chemist must be a practical man, able to tell the reason for a failure and the way to improve or remedy it. He will also have to work in collaboration with and be consulted by the chief engineer on all metallurgical questions so as to produce any required material with its specified mechanical properties.

To carry out his duties efficiently the metallurgical chemist must be a good organiser.

### Organisation of Laboratories.

The first department to organise will be the laboratory, which will work in conjunction with the raw material stores. For this we suppose that he has at his disposal the necessary equipment required for testing materials used in the manufacture of motor cars. The usual chemical laboratory equipment will be laid down under his supervision. We shall not give any data regarding the lay-out of such, but mention only that it must be organised so as to carry out analysis rapidly and accurately. The mechanical testing laboratory will comprise a 30-ton tensile machine, very necessary nowadays, as steels up to 90 tons per sq. in. and even more have to be tested. Torsion, compression, bending, and transverse cast iron tests will be made on the tensile testing machine. An Izod testing machine, using a circular Izod test-piece, will be needed for the impact test, the 120 ft. lbs. being the most convenient. It is also useful to have an alternating stress testing machine, such as Stanton, Sankey, or Arnold. Besides these machines the Brinell and Scleroscope have their use and should form part of the equipment. Laminated springs can be tested on the transverse bar of the tensile testing machine. Some machines, such as Avery's 30-ton, have a 5-ton jockey attachment, which is very useful for the testing of small test-pieces or low tensile material as well as for the springs mentioned above. Included in the equipment will be a drilling machine, grinding machine, and a lathe, which will be used for the machining of test-pieces as well as for the testing of all tool steels, both cast and high-speed, coming into the works. As the metallurgical chemist is well accustomed to all the above tests, we do not propose giving any details of these our object being to give extensive information on organisation and the relation between the works and the chemist.

INWARDS DEPARTMENT TO LABORATORY. 201

DATE.....

| Material. | Maker. | Description. | Size. | Quan. received. | Part No. | Spec. No. | Analysis No. | Sanction | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
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Fig. 1.—*Form on which the Inwards Department advise the Laboratory of the receipt of Raw Material.*

ANALYSIS No.....

Date .....

| | | |
|---|---|---|
| C | Al | Sb |
| C Gr. | Si | |
| Mn | W | |
| Ni | Cu | |
| Cr | Pb | |
| Va | Zn | |
| P | Fe | |
| S | Sn | |

Fig. 2.—*Envelopes designed to contain samples for analysis.*

To organise the laboratory and to enable work to be carried out with the greatest efficiency, it will be necessary to have the following books and cards printed:—(1) Inwards department to laboratory with perforated duplicate; (2) envelopes with symbols; (3) analysis No. card with all information; (4) subject reference cards; (5) heat treatment book with perforated duplicate; (6) report book with all information regarding tests, with perforated triplicate sheets; (7) tool-steel testing cards. These are shown in Figs. 1 to 7.

In order to facilitate easy working of the routine, it has been found desirable to have an inward department, where all material is acknowledged and then placed at the disposal of the laboratory. It is the duty of the superintendent of the inwards department to sample all material according to laboratory instructions. The sampling is a very important operation, as the samples taken for analysis are very small and are taken as representing the average composition of a consignment. We have found that always having the same man to take samples is an advantage, as he knows the exact requirements. As an example, for a truck of coal the sampling would be done whilst unloading by means of samples taken at regular intervals. Pig-iron would be similarly treated. With regard to worked material, such as castings, forgings, stampings, or bars, sampling would be done on a percentage proportional to the size of the material. The sampling being accomplished, the samples should be prepared in a convenient form for analysis such as drillings, crushings, or if liquid, in a sealed bottle. Drillings or crushings will be placed in the envelope (Fig. 2),

which will bear a number, which number should be transferred to the card, shown in Fig. 3, and all information regarding the sample should be recorded. In the book (Fig. 1) the inwards department will enter the number of samples together with all necessary information. Books, samples, and cards will then be sent to the laboratory. A sequence of two books (Fig. 1) will be necessary in order to facilitate routine and to avoid delay, one being in the laboratory and the other in the inwards department. All samples must reach the laboratory at least one hour before work ceases. Whilst the samples are being dealt with all items will be entered on the card, shown in Fig. 4, so as to establish at once the analysis number of a certain material, known only by its name—say, connecting rods, crankshafts, coke, etc. All results should be recorded in the writing of the chemist or physicist on the back of card shown in Fig. 3, so as to fix the responsibility in case of disagreement. All results should be passed by the chief chemist. Reports from outside firms should be recorded in the book, shown in Fig. 5. Only material which does not come up to specification should be reported to the chief engineer. In the case of a foundry, all castings should be analysed according to routine. For heat-treatment, test-pieces will be supplied, integral with important parts, or obtained by taking a percentage on small parts. Tool steel (cast and high-speed) will be analysed, following the same routine. A special test should be made so as to ascertain whether the cutting efficiency is at its maximum. Improvements can thus be made by the chemist in order to facilitate the smooth running of the factory.

In the case of a motor car works without a foundry, but with a heat-treatment department, the steels which might be used are so numerous that it is impossible in an article of this nature to deal adequately with them. It is proposed

| Mat. | Maker. | Size. | Reg'd. for | P. No. | S.S.Ltd. No. | Spec. No. | Treatment. | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

| Chemical analysis. | | Physical tests. | | Micro. No. | Remarks. |
|---|---|---|---|---|---|
| | | Y. P. | | | |
| | | M. S. | | | |
| | | El. % | | | |
| | | Red. Ar. | | | |
| | | Impact | | | |
| | | Brinell | | | |
| | | Scleroscope | | | |

Fig. 3 *represents two sides of the laboratory record card.*

| DATE. | MATERIAL. | REF. No. | |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Fig. 4.—*The Subject Reference Card.*

MESSRS. SMITH AND SMITH, LTD, LONDON : 1

NOTE.—ALL SPECIMENS TO BE PROVED TO DESTRUCTION.

| Makers. | Class of material. | ARTICLE FOR TEST. | | | | | CHEMICAL ANALYSIS. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Date. | Nature of article. | Spec. No. | Part No. | Analysis No. | C. | Gr. | Si. | M. | P. | S. | | Analyst. |
| | | | | | | | | | | | | | | |
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| HEAT TREATMENT. | | | PHYSICAL TEST. | | | | | | | | Micro. No. | Reported by | Checked by | Releasing date. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ACTUAL. | | | | | | | | | | | |
| Carbonising temp. | Hardening temp. | Tempering temp. | Y. P. | M. S. | El. % | Reduct'n of area. | Izod. | Nature of fracture. | Brinell. | Scleroscope. | | | | |
| | | | | | | | | | | | | | | |
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Fig. 5 *shows a report-book designed to give complete information. Each page is duplicated.*

therefore to consider about fifteen steels, classified as follows:—(*a*) Case-hardening steels; (*b*) carbon steels; (*c*) alloy steels.

**Nomenclature.**

Before giving any results obtained, it may be perhaps advisable to define the various terms used.

*Critical Point.*—This may be defined as the temperature above which the constitution of the steel changes. This new constituent can be either fixed by rapid cooling or destroyed by slow cooling. Steels may have one, two, or three critical points. In all cases the complete change of constitution always occurs above the highest critical point on heating. Critical points on heating are determined by a recording pyrometer. The steel to be examined is placed in contact with the hot junction of a thermo-couple usually made of platinum and an alloy of platinum with 10 per cent. rhodium. The difference in temperature between the hot and cold develops an electro motive force. The circuit is connected to the two terminals of a galvanometer, the needle of which is so arranged as to automatically record the temperature, which when taken with regard to regular time intervals shows up any time lags or leads. Suitably plotted a heating curve will then be recorded. This curve will be uniform until any change in the structure of the steel takes place. When this occurs the heating curve will show an arrest, this being due to the absorption of heat produced by the change of constitution of the steel under examination. There may be one, two or three stops in the curve, according to the carbon content in the steel. The critical point temperature is inversely proportional to the carbon content, *i.e.*, steel with 0.1 per cent. carbon will have three critical points; the highest being at 890 deg. C., while 0.9 per cent. carbon steel will be the three critical points compounded in one at 690 deg. C.

Alloy steels show critical points as well as carbon steels, but at different temperatures according to their analysis.

*Annealing.*—The material is heated up to above the higher critical point on heating and cooled slowly in furnace away from contact of air. The object is to destroy any overheated structure due to casting, forging or any previous heat-treatment.

*Normalising.*—In this case the steel is heated up in annealing but cooled inside the furnace in still air. The object is to destroy any light forging strains or machining stresses, or to soften the steel to ease machining, or to destroy any previous heat-treatment.

*Hardening.*—Heated up as in normalising, and cool either in brine, water, oil, blast or still air. The object is to obtain a harder steel with new mechanical and physical properties. The temperature should be 50 deg. C. above the higher critical point of heating. At that temperature the size of the crystals can be considered as normal. If the temperature is higher than 50 deg. C. above the critical point the size of the crystals will grow proportionately to the temperature, *i.e.*, the higher the temperature, the larger the crystals. The higher the carbon content, the larger the crystals for the same temperature. If a steel is brought up to a very high temperature, say, 1,100 deg. C., and cooled down to 900 deg. C., the size of the crystals will remain the same, they do not contract; but if cooled down to 500 deg. C. and heated up again to 50 deg. C. above the critical point, the size of crystal will be normal.

*Time.*—This is an important factor—steel must be left at the correct temperature for a definite time, proportional to the size of steel, so as to obtain a uniform temperature throughout the metal. If the steel is left longer than the required time the size of crystals will increase proportionately to the duration.

*Tempering.*—This process consists in heating hardened steel to below the higher critical point temperature so as to obtain new mechanical properties, which, as a rule, are improved. Tempering lowers the maximum stress and the elastic limit, but improves the elongation, reduction of area and impact values.

*Over-heated Steels.*—This denomination must not be confused with "burning." Overheating has reference to a steel that has been heated up

100

| Material. | Part No. | Description. | Carbonising. Time. In. | Carbonising. Time. Out. | Carbonising. To C. furnace No. | Hardening. Time. In. | Hardening. Time. Out. | Hardening. To C. furnace No. | Tempering. Time. In. | Tempering. Time. Out. | Tempering. To C. furnace No. |
|---|---|---|---|---|---|---|---|---|---|---|---|
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Fig. 6 *is a form of report-book giving all information regarding case-hardening tests. Each page is duplicated.*

Analysis and Test No. .....

Forging temperature degree Centigrade .....

Size of Tool .....

Clearance angle .....

Back slope .....

Side slope .....

Annealing Temperature .....

Hardening Temperature ..... bath .....

Tempering Temperature ..... bath .....

Grinding ..... Stone grade .....

Efficiency Test:

Lubricant ..... Cooling .....

Speed (feet per minute) .....

Feed (inch per revolution) .....

Cut (depth) .....

Weight of material removed per minute between each grinding .....

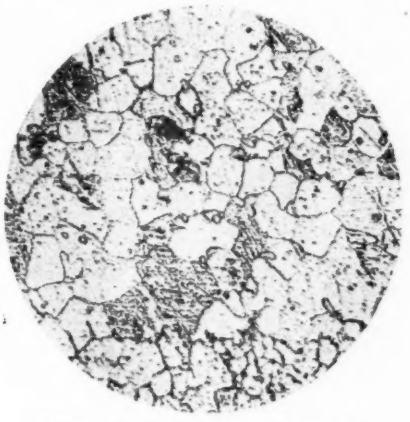
Life of tool before ruination .....

Cutting efficiency compared against standard steel .....

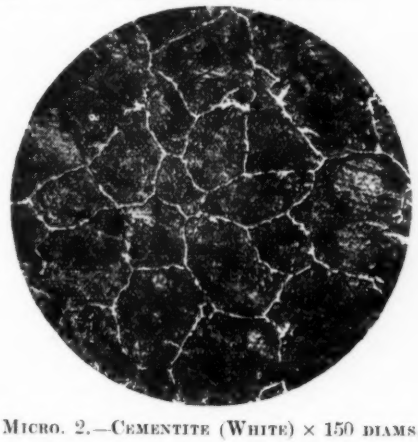
Remarks .....

Fig. 7.—*Shows the two sides of the card designed for recording Tool Steel Tests.*

to more than 50 deg. C. above the critical point, but below the softening point. Overheated steels can be regenerated by reheating them slowly to the correct temperature and cooling them either rapidly or slowly. All steels, although heated at the correct temperature, can be overheated by being left too long at that temperature.

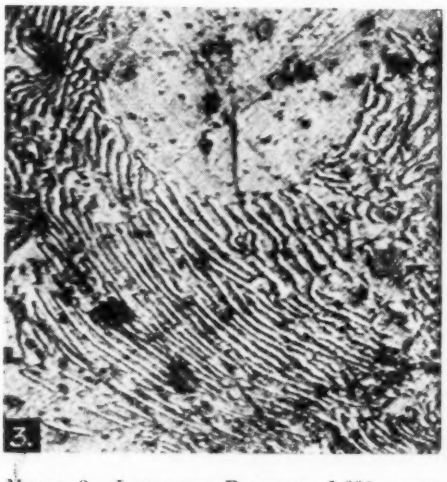


MICRO. 1.—FERRITE × 150 DIAMS.



MICRO. 2.—CEMENTITE (WHITE) × 150 DIAMS.

*Burnt Steels.*—Steels, heated up to softening temperature, at which the oxygen contained in the air produces oxydised films which cannot be destroyed unless the steel is remelted by a normal manufacturing process, are designated "burnt."



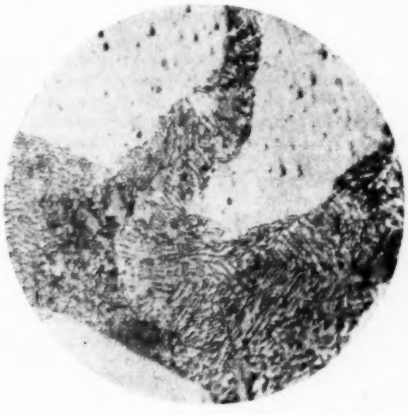
MICRO. 3.—LAMINATED PEARLITE × 1,000 DIAMS.

### Micro-Constituents.

Only those terms which are the most commonly used in connection with automobile steel will be dealt with.

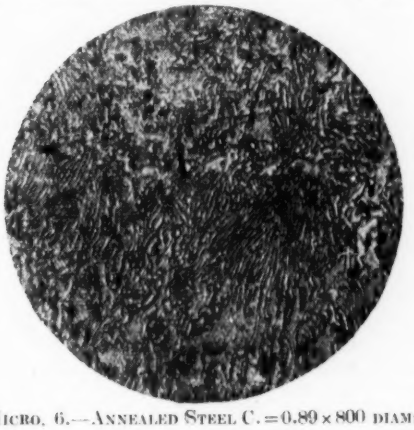
*Ferrite.*—This constituent is composed of nearly pure iron. Ferrite is soft and weak, sustaining about 18 to 20 tons per sq. in. maximum, and very ductile. Its critical temperature is over 890 deg. C. Microphotograph No. 1 shows the appearance of ferrite at a magnification of 150 diams.

MICRO. 4.—ANNEALED STEEL C. = 0.11% × 800 DIAMS.



MICRO. 5.—ANNEALED STEEL C. = 0.65%.

*Cementite.*—The carbide of iron ($Fe_3C$), *i.e.*, carbon combined with pure iron or ferrite, is the hardest constituent of steel, and is metallographically termed cementite. It scratches glass and felspar, but not quartz, and is very brittle. Carbon in the steel will then be as a compound, if in the free state it will be as primary graphite, as in cast iron, or as temper carbon or secondary graphite, as in malleable iron. The white constituent in microphotograph No. 2 is cementite.



MICRO. 6.—ANNEALED STEEL C. = 0.89 × 800 DIAMS.

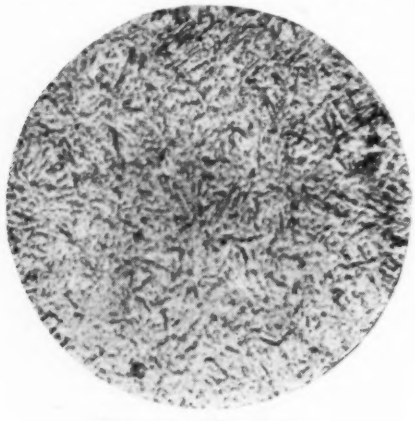
*Pearlite.*—This is a mixture of seven parts of pure iron (ferrite) to one part of carbide of iron (cementite). When pearlite is considered as normal, it shows a laminated structure and contains 0.9 per cent. carbon, as shown in micro-

photograph No. 3. The critical temperature of pearlite is 690 deg. C. Carbon steels in the annealed state will always contain two components, *i.e.*, pure iron, as ferrite, and carbon, as carbide of iron, or cementite. It will be easy to understand that the higher the carbon content, the greater will be the percentage of carbide of iron formed, and the smaller will be the pure iron content.

MICRO. 7.—ANNEALED STEEL C. = 1.50% × 150 DIAMS.

*Annealed Steel.*—In steel containing less than 0.9 per cent. carbon, the carbide of iron is always associated with pure iron, and forms a lamellar structure called pearlite, as mentioned above. It is called eutectic steel, the word being derived from the Greek—"Eutektos," "Eu" well, "teko" fuse, or a constituent which melts readily or at a low temperature. It is said of a compound substance that it has a lower fusing point than its components have individually. Microphotograph No. 4, wherein the dark area is pearlite and the light area is ferrite, has reference to a steel in the annealed state, and contains 0.108 per cent. carbon. Therefore, as pearlite contains 0.90 per cent. carbon, the dark areas will occupy 12 per cent. of the total area, the other 88 per cent. consisting of nearly pure iron.

Microphoto No. 5 shows a medium carbon steel annealed, of a carbon content of 0.64 per cent., the dark areas being pearlite occupying 72 per cent., leaving 28 per cent. occupied by the ferrite.

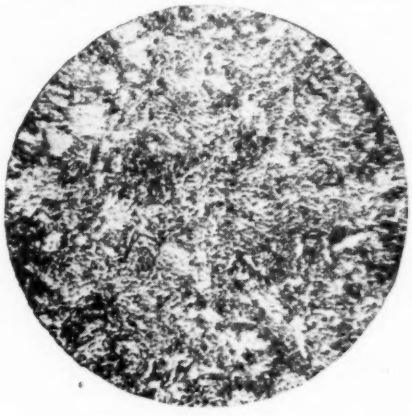


MICRO. 8.—MARTENSITE.

Microphoto No. 6, representing a steel in the annealed state, contains 0.89 per cent. carbon, *i.e.*, 100 per cent. pearlite area. All the above figures are as near as possible to the theoretical figures. The last steel can be considered as *eutectoid steel*, *i.e.*, of a eutectic nature.

Above 0.9 per cent. carbon, the percentage of pearlite decreases in all annealed carbon steels, as the carbon content increases, because the proportion of carbide of iron to be associated with pure iron to form pearlite is overbalanced and is then thrown out as free. This is the reason why it can be seen as white hard needles, forming a network, which is filled in by pearlite, as in the Micro. No. 2, and contains 1.1 carbon, and in Micro. No. 7 containing 1.5 per cent. carbon. All steels above 0.9 per cent. carbon are called "hyper eutectoid" steels—hyper meaning "in excess," from the Greek "Huper."

*Martensite.*—This is the chief constituent of all properly hardened carbon steel, and is shown in Micro. No. 8. Where steel is heated to a correct temperature above the critical point, all constituents are supposed to enter into solution, and is fixed in that state by sudden cooling, they appear under microscopic examination as needles parallel to the side of a triangle.



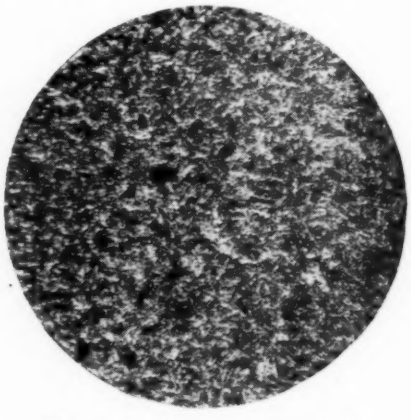
MICRO. 9.—AUSTENITE.

*Austenite.*—This is the constituent of all steels which have been overheated, such as castings, forgings, or badly-heated tool steels. Under the microscope this appears a dark mass pierced by long interlacing needles, as shown in Micro. No. 9.

*Sorbite.*—This constituent is found in all tempered steels (usually above 400 deg. C.). It has an ill-defined structure of black and white patches, as in Micro. No. 10.

From the above detailed account the following conclusions can be drawn, for all carbon steels, 1 to 5 per cent. nickel steel and 3 per cent. nickel-chrome steels or chrome-vanadium steel:—

(1) That in the annealed state the structural constitutions will consist of ferrite of pearlite. (2) In the hardened state, the structural constitution will be martensitic. (3) In the overheated state the structure will be austenitic, and in the tempered state sorbite will be the structure sought for.



MICRO. 10.—SORBITE × 300 DIAMS.

*(To be continued.)*

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MR. MYLES KENNEDY, chairman of the Lancashire and Cumberland Conciliation Board for the iron-ore industry, has stated that the men in the mines with which he is connected in Furness have voluntarily agreed to their wages being based on current selling prices of ore, instead of the price for the preceding two months. That involved a reduction of 3s. 1d. per day.

## Book Review.

ENGINEERING CONSTRUCTION. By William Henry Warren.—London: Longmans, Green & Company, 39, Paternoster Row, E.C.4. (Price of Vol. I., 30s. net; of Vol II., 36s. net.)

Vol. I. is a revised (third) edition of a book first published in 1894 under the title "Engineering Construction in Iron, Steel and Timber," with additional appendices on (*a*) Australian timbers, and (*b*) on recent steel column experiments and formulæ. The first chapter is devoted to stress and strain, the properties of cast iron and steel, the determination of safe working loads in structures, and other subjects in connection with the elastic theory of materials. It mentions the history of the first cast-iron bridge built in 1776-79 by Abraham Darby, at Coalbrookdale, which stood until 1902 when it partially gave way but was repaired under the supervision of the late Sir Benjamin Baker, who pronounced it good enough for another hundred years. It consisted of cast-iron arched ribs like old Southwark Bridge recently demolished. Cast-iron girders are dealt with on pages 120 to 123. In cast-iron beams of proportions similar to the one shown in the book, the lower, that is the tension flange, will always be the weaker of the two, and it always must be because if the area of the top flange were reduced so as to make its compressive strength more nearly equal to the tensile strength of the lower flange, the form of the section would not be so suitable, if at all, for casting, as the thinner top flange would cool first and there would be a danger of a flaw in consequence of the retarded contraction of the thick bottom flange. Moreover, the top flange if reduced to the size allowed by theory would most probably buckle laterally, even if embedded in brick arches or concrete. Cast-iron beams have the advantage over steel girders that their depth can be varied by curving the upper or both flanges, a most expensive device in the case of plate girders in steel.

For cast-iron columns we are referred in the index to pages 253 to 274, where the strength of columns in general is dealt with, but not a word is found about the designing of cast-iron columns or stanchions. Columns and stanchions built up of steel will, no doubt, be preferred in many cases, but they cannot be treated in the same artistic fashion as can be cast-iron columns.

We note that the author has duly introduced Sir Benjamin Baker's formula for the practical strength of beams, but we must join issue with him when he states that if the elastic limit of the material is not exceeded, the theoretical formula is a rational one, and may be used for finding the intensity of the stress in the extreme fibre in any section. A few practical tests would convince the author of the contrary. For this reason a sharp distinction is made nowadays between the tensile stress in bending and that found by direct pull.

Vol. II. is mainly devoted to considerations of the physical properties of cement, mortar, concrete, brickwork, stone, etc., and to the design of the more usual structures built of these materials, foundations, etc.

### Publications Received.

"HEAT-TREATMENT OF CARBON TOOL STEEL," by Lancelot W. Wild, M.I.E.E., Automatic and Electric Furnaces, Limited, 281-283, Gray's Inn Road. London, W.C.1.

MESSRS. GEO. W. WHEATLEY & COMPANY, LIMITED, 95, Upper Thames Street, E.C.4. Booklet, showing at a glance the cost of telephone calls under the new method of charging by distance between subscribers connected with the Exchanges within the inner London zone, of which a list is also given.

MESSRS. CONSETT IRON COMPANY, LIMITED, Consett. Co. Durham. "Silica Bricks, Sizes and Description," "Schedule of Sectional Material' and Prospective Programme of Same."

MESSRS. ENGINEERING & COLLIERY APPLIANCES, LIMITED, Rockingham Street, Sheffield. "Ecal Hack Saw Blades," Standard price list.

MESSRS. CHARLES B. PENWARDEN & COMPANY, Station Buildings, Altrincham, Manchester. "Power o' Print," a magazine for advertisers.

## Queries Answered.

### Electric Steel Castings.

O 1.—I should be glad if you could say what special precautions should be taken to ensure that steel castings produced by the electric furnace process should be capable of withstanding a steam or hydraulic pressure of 600 lbs.?—W. H. W.

O.2.—We would advise our correspondent to work to the following specification—C. 0.45, Mn. 1.00, Si 0.20, S. 0.02 and P. 0.03. The steel should be teemed under a white (not grey) desulphurising-deoxidising slag at a fairly high temperature.

The fault usually found is a too low manganese and carbon content associated with too much silicon.

### Area Ratio of Tuyeres.

J2.—We consider this and its allied subjects so important that we are publishing in this issue an article on these questions. Briefly stated, the ratio of tuyere area should increase as the cupola diameter diminishes. Figures which we have recently seen advocate a ratio of 1 to 6 for small cupolas, 1 to 7 for furnaces of 4 to 5 ft. diameter, and 1 to 8 for larger sizes.

### The Use of Borings in the Cupola.

C.5.—In reply to H. C. the use of a binder depends entirely upon the nature of the briquetting-plant used. There is, so far as I know, no satisfactory plant made in this country. The remarks I previously made were based upon the general system in use in America where briquetting is carried out to a very large extent. Briquetting in this country is chiefly confined to the conversion of anthracite culm into merchantable fuel, but wherever and whenever a fine material is produced as an incident to operation—a fine material whose return to a coarser size would be of benefit—a field is open to this most modern use of scrap. With the plant I had in mind, briquettes are made by a toggle press—pressure about 3 tons per sq. in.—and also by hand press by pressures of about 10 cwt. Binding by lime and water is rarely used, except in very small briquets made of very small material, but it is always found that in using such a binder it is very necessary to treat the briquets to accelerate the setting of the lime. By experience it has been found that where a material, such as blast-furnace flue dust, has failed to give a good briquet with pressure only, if a catalytic agent is used as a binder it removes all difficulties, in this case the catalyzer used is ferrous sulphate, which while possessing in itself no binding or cementing power, produces a chemical action in the material and results in cementation. —T. V.

## A Canadian Foundry Extension.

The "Canadian Foundryman" announces that the Joliette Castings & Forgings, Limited, of Joliette, Quebec, have recently completed the installation of a one-ton "Greaves-Etchells" electric furnace for the manufacture of manganese steel and alloy steel castings, particularly for the making of wearing parts for mining machinery. A 5-ton Northern electric travelling crane has been installed in the new building and extended to the fettling shop. The castings are to be annealed in a continuous oil-fired furnace. They have also built a new sand-blast house equipped with Pangborn sand-blast. A new power-house and machine-shop has been erected with the necessary machinery for facilitating delivery of finished castings and specialities.

ACCORDING to a French paper, the Pont-à-Mousson works in the Meurthe-et-Moselle have secured an important order from the Sheffield Water Committee at a price considerable under that quoted by British firms.

LICENCES under the Non-Ferrous Metal Industry Act, 1918, have been granted to Derby & Company, Limited, 37-38, Hatton Gardens, E.C.1; R. C. Griffiths, 14-20, St. Mary Axe, E.C.3; and W. J. Onions, 3, New Street, Birmingham.

XUM

# Trade Talk.

BARON EDMOND DE ROTHSCHILD has given 10,000,000 francs to found an institute for scientific research with a view to developing the application of science to industry and agriculture.

THE BOARD OF MANAGEMENT of the Railway Benevolent Institution have decided to abandon the annual dinner, postponed from May 10, in consequence of the coal crisis and the restricted service of trains.

THE VICTORIAN GOVERNMENT has accepted the tender of Messrs. Babcock & Wilcox of £178,000 for the installation of a boiler plant for the Newport power house, which is part of the Morwell electricity scheme.

A NEW steel pontoon grab dredger named the "Tyne" has just been completed by Messrs. Henry Robb, Limited, Leith, for the Tyne Commissioners. The dredging plant, crane, and machinery were supplied by Messrs. Priestman Bros., Limited, Hull.

A NEW organisation, the Federation of British Propaganda Societies, has been formed, with the Duke of Northumberland as president, to co-ordinate the work of propaganda societies. The general secretary is Mr. David Gilmour, Sicilian House, Southampton Row.

DURING April the output of pig-iron in Belgium totalled 96,230 tons, which compares with 106,360 tons for the previous month and with 94,043 tons monthly average for 1920. It may be remarked that the average monthly production of 1913 was 207,058 tons.

THE PROVIDENCE IRON WORKS, Marchienne au Pont, has obtained an order for 9,500 tons of rails, etc., for the Argentine State Railways. Payment is to be made in six-monthly Treasury bills. A number of Belgian, French, etc., firms had submitted tenders for this contract.

THE electric steel foundry of the J. W. Cumming Manufacturing Company, New Glasgow, N.S., is now in operation, under the direction of J. M. Robertson, Montreal, the designing engineer of the plant, and C. A. Pascoe, metallurgist, and Sanford Davis, electrical engineer, of Montreal.

MESSRS. HARLAND & WOLFF have supplied Brown-Curtiss double-reduction geared turbines of 3,000 h.p. to the new steamer "Burgerdyk," of 6,800 tons gross, built in Holland for the Holland-America Line, and the vessel has now left Belfast to take up sailings in the Dutch East India trade.

THE CANADA IRON FOUNDRIES, LIMITED, Fort William, Ont., are now preparing plans for a $150,000 addition. This will be a foundry for the manufacture of car wheels, and will be equipped with facilities for turning them out by a different process than that of the old familiar man power.

THERE have been built and equipped at Penistone by Cammell Laird & Company, Limited, excellent model steel works, and the firm is completing a model garden village for the steel workers. It is the first instance of a distinctly Sheffield steel firm building a model village for its employés.

BESIDES the unemployment caused by lack of orders in various shipyards at Genoa and elsewhere, Armstrong's, at Pozzuoli, near Naples, has now had to begin discharging employés. Five hundred have already been dismissed, and a further reduction is probable, so as to reduce the total number of employés to 500.

THE ELECTRIC FURNACE CONSTRUCTION COMPANY, Philadelphia, announce that the 10-ton "Greaves-Etchells" electric furnace installed by their English office at the works of the Sociedad Espanola de Construccion Naval, Spain, has been successfully started up. This is the first large electric furnace to be operated in Spain.

WHEN the hearing of the compensation dispute between the North British Railway Company and the Ministry of Transport, involving a sum of £430,000 claimed by the company, was resumed, the Tribunal was informed that the Minister could not accept the proposed settlement. The Tribunal decided that there should be an inquiry.

RICH copper deposits are reported to have been discovered at Sandwick, in Shetland, where extensive shaft-sinking operations have been proceeding for several months. The consulting engineers report large resources, particularly in two lodes, one revealing, by means of a 300-ft. shaft, about 90,000 tons of ore, and the other 294,000 tons.

DURING the recent visit of the Duke of Devonshire to the plant of Baldwin's Canadian Steel Corporation at Toronto, Mr. Cound (managing director) said that it was the intention of the company to make Toronto still a larger tinplate manufacturing centre, plans having been already made for the establishment of a number of additional sheet mills.

A FEW days after the opening of the new Southwark Bridge, some of the plant used in the manufacture of the old structure was demolished by explosives at the works of the Park Gate Iron and Steel Company, of Rotherham, now owners of the premises where Messrs. Walker performed the feat of casting the bridge, which weighed between 5,000 and 6,000 tons.

EXPORTERS to Canada should bear in mind that on and after September 1 next all goods imported into the Dominion which are capable of being marked without injury, must be marked or branded with the name of their country of origin, this being obligatory under the penalty of an additional duty of 10 per cent. *ad valorem* on the goods.

MR. MYLES KENNEDY, chairman of the Lancashire and Cumberland Conciliation Board for the iron-ore industry, has stated that the men in the mines with which he is connected in Furness have voluntarily agreed to their wages being based on current selling prices of ore, instead of the price for the preceding two months. That involved a reduction of 3s. 1d. per day.

THE New Zealand Government has placed orders in Great Britain for 45 large locomotives, 2,500 wagons, and 12,000 tons of rails, the sum involved being two millions sterling. In addition, the Dominion is having executed over here extensive plant for hydro-electric works. It is now announced that the contract has been placed with the North British Locomotive Company, Limited.

A REUTER cable from Melbourne states that in the course of the discussion on the Customs tariff the House of Representatives agreed to the admission, free of duty, of British traction engines of kinds not made in Australia. The duties on cables were also fixed as follows, with effect from October 1, 1922: British preferential, 35 per cent.; intermediate, 40 per cent.; general, 45 per cent.

VERY good work has been done by the Trade Marks, Patents, and Designs Federation in the first year of its existence. The Federation was promoted by a number of the leading industrial undertakings in this country, and is receiving the support of the Federation of British Industries in co-operation with important associations in Germany, Italy, America, Egypt, Spain, Argentina, Brazil, and other countries.

AT a recent meeting of preference shareholders in the Leeds Fireclay Company, Limited, and presided over by Mr. S. E. Grimshaw, the following gentlemen were elected as a committee for the purpose of safeguarding the interests of the preference shareholders:—Sir Robert Elliott-Cooper, Colonel T. W. Harding, Mr. R. M. Currer Briggs, Mr. Ernest Terry, Mr. Grosvenor Talbot, and Mr. Henry Lupton.

THE BRITISH ENGINEERING STANDARDS ASSOCIATION has formed seven sub-committees in connection with the movement towards the standardisation of automobile, motor-cycle, and cycle parts. These sub-committees are appointed respectively to deal with (1) nomenclature, (2) steels, (3) small fittings, (4) electrical fittings, (5) shafts and shaft details, (6) wheels, rims, and tyres, and (7) cast iron.

IT is reported that a large contract for axles for the Indian State Railways, which was expected to have come to Messrs. Beardmore & Company, and the Steel Company of Scotland, has been placed in America at about 30 per cent. below the prices which the Scottish makers were able to quote. It is stated that this is the first time that such a contract for the Indian State Railways has gone outside Britain.

A MASS meeting of the workers of Messrs. David Colville & Son's Dalzell Works, Motherwell, decided to offer to start work and continue without interruption during the usual Fair holidays without payment of the usual time and half for the Fair holiday period. A representative of the Confederation of Iron and Steel Workers pointed out that a guarantee had been given by the firm that this would not form a precedent for the future.

A SETTLEMENT was reached at a conference held at the Hotel Russell, London, in regard to wage reductions affecting 50,000 workers in the railway wagon and carriage building and repairing trades. Alderman Percival Bower, Birmingham, presided on the men's side, and Mr. Duncan Bailey on the employers' side. The conference agreed on a joint recommendation for a wage adjustment on the following basis:—3s. per week reduction for time workers and 6 per cent. for piece workers, to take effect from July 1, and a further reduction of 3s. and 5 per cent. from August 1, making a total of 6s. and 10 per cent.

THE COMMERCIAL COUNSELLOR TO HIS MAJESTY'S EMBASSY AT ROME (Sir Edward Capel Cure) has received an application for the names of any British firms who are in a position to supply 50,000 metal casks to contain petroleum and benzine. The casks should be made of iron, zinc coated inside and outside, and each provided with two iron hoops and two copper screw stoppers. The net capacity of each cask is given as 150 kilos, and the weight when empty 50-55 kilos. If possible prices should be quoted for delivery c.i.f. Savona duty free. United Kingdom firms interested in this matter may obtain full particulars on application to the Department of Overseas Trade, 35, Old Queen Street, S.W.1.

# IRON AND STEEL MARKETS.

## Pig-iron.

The settlement of the prolonged miners' dispute, the return to work, and the consequent early resumption of fuel supplies, have, so far, had little favourable effect in pig-iron markets, which remain in the lethargic condition which has so long characterised the trade. Home production is now at the lowest ebb ever recorded in the history of the industry, and notwithstanding the optimistic utterances of the Prime Minister predicting an early return of activity, market movements are entirely confined to the limited requirements of the few home consumers in a position to continue partial operations. In the Cleveland market foreign inquiries have practically ceased, and the export premium of 5s. per ton is purely nominal. Foundry qualities of pig-iron are now almost unobtainable, supplies being nearly exhausted, while the lower numbered irons, although still plentiful, are in very poor demand. Cheap German iron, too, is now finding its way into the various European markets, and even into Italy, while Belgian and Luxembourg foundry iron is procurable in this country at a c.i.f. price of not more than about £5 per ton, as against £6 10s. for Cleveland No. 3. Meanwhile quotations are unchanged as follows :—No. 1, 135s. ; No. 3 G.M.B., 130s. ; No. 4 foundry, 129s. ; No. 4 forge and mottled, 117s. 6d. ; white, 115s. In the Manchester foundry iron market there is still a little business possible at £9 delivered to Manchester, but now that the prospect of re-starting some of the furnaces is brighter, sellers of foundry iron are more inclined to accept orders for the few tons yet remaining. Midland smelters will not attempt to quote forward because, so far, they have no reliable indication of the price of coke although the strike is at an end; and they declare that unless there is a substantial reduction it will not be any use their blowing in the furnaces because they could not work them profitably. There is still some forge iron in stock, but it is more or less a drug in the market.

Mixed numbers of East Coast hematite are still freely obtainable at 160s., and No. 1 at 162s. 6d. per ton, but there is scarcely any demand, and even the offer of iron for export at 150s. does not attract business.

## Tinplates.

In common with other branches of the industry, business in the tinplate section is still affected by the general stagnation resulting from the stoppage of fuel supplies. Numbers of works could restart at once with orders still in hand if the coal could be procured, but the difficulty manufacturers are under is that no delivery dates can be guaranteed, whereas foreign makers can definitely specify. For coke tins, 25s. is quoted for delivery, after works resume operations, but prompt parcels command 27s. basis and upwards, net cash, f.o.t. Wasters are in fair demand, CW. 28 by 20 are worth 40s. ; CW. 14 by 18¾, 16s. 6d., and CW. 20 by 10, 22s. 9d. to 23s., all net, f.o.t. Lighter substances are scarce, and realise good prices. For ternes, 26s. 6d. basis is being quoted for forward delivery. This figure is quite nominal, however, no transactions worth mentioning being reported.

## Finished Iron.

Markets for finished iron of all descriptions remain in a condition of uncertainty, few producers having fuel facilities for operating plants except where electric power is available, with the result that most of the mills are idle or working short time only. Very little business has developed since the lowering of the Staffordshire marked bar standard, makers not knowing when they will be in a position to ensure deliveries, or what prices they will have to pay for raw materials, while in some cases the lack of fresh specifications adds to the difficulties of the position. It is, however, generally recognised that the reduction of prices has been the right step in the direction of counteracting outside competition, especially in the commoner grades of crown bars, for which in the Midlands it is expected there may shortly be an increased demand by nut, bolt and rivet makers. Of late a too large proportion of this material has been supplied by Continental producers, but it is hoped that with more reasonable prices for raw material and fuel in the near future, home manufacturers will be better able to hold their own in competitive conditions. Makers of marked bars are still in possession of fairly well-filled order books, deliveries having been delayed for obvious reasons, while the depleted state of merchants' stocks should also ensure a renewed demand when the mills are restarted. Recent reductions are shown on our price list page.

## Steel.

So far very little evidence is forthcoming of any improvement in the steel trade resulting from the recent drastic revision of prices for the principal products, which have not as yet served to stimulate either the home or the export demand for material. The stagnation which has overtaken the industry since the termination of the boom continues alike in home and foreign production, more especially affecting the heavier branches of the trade, the cessation of armament work, and the inactivity of the shipbuilding trade having resulted in an almost complete stoppage of the big mills and forges. The failure of foreign demand is a further factor of importance in the position of the steel trade, any hopes that might have been entertained of an increase of export transactions with Russia following the recent negotiations with the Soviet Government having entirely disappointed expectations. Continental competition on price-cutting lines continues with unabated vigour, Belgian soft billets, for instance, being freely sold delivered British ports, and although this material is of comparatively little interest to Sheffield manufacurers, the influx of this material is naturally not without its effect upon local trade. From Glasgow is reported that a valuable contract for axles for the Indian State Railways has been lost to the Scottish steel workers. It has gone on a strictly price basis to American competing firms. The reduction in quotations for steel plates and sections is not sufficient to attract buyers. Scottish sheet makers report a fairly good accumulation of orders when they resume rolling, but the prospects for the future do not look too bright owing to foreign competton. In the Midlands most of the business passing is in imported steel. There has been a little British material available, but the quantity is insignificant. When trade is possible again manufacturers will find the position very difficult because of the price at which Continental "semis" can be purchased.

## Metals.

**Copper.**—Messrs. Henry Bath & Son, Limited, in their fortnightly metal report, state :—"The labour situation continues to be the governing factor in market movements. The conditions in England have brought trade to a standstill, but one result of the cessation of production is the steady diminution of retailers' stocks and manufactured goods abroad, pointing to a good demand when our manufacturers can again get to work always provided that reduced costs will enable them to compete with Continental conditions." In this week's opening markets, standard copper developed a stronger tone with a more active buying tendency on consumers' account, doubtless stimulated by the improvement reported in the labour outlook. Values showed only slight fluctuations throughout, the close being steady and marking an advance of 20s. for both positions. Electrolytic and wire bar advanced 10s. to £74 7s. 6d. Closing prices : —Cash : Wednesday, £70 5s. ; Thursday, £69 12s. 6d ; Friday, £69 7s. 6d. ; Monday, £70 12s. 6d. ; Tuesday, £70 5s. Three Months : Wednesday, £70 5s. ; Thursday, £69 17s. 6d. ; Friday, £69 12s. 6d. ; Monday, £70 17s. 6d. ; Tuesday, £70 12s. 6d.

**Tin.**—Eastern cables advising sales of 150 tons at £169 c.i.f. at Monday's opening market for tin showed a decline of 5s. under the previous business done, but had little effect upon movements on this side. The stagnant condition of the tinplate trade will probably explain the absence of any extensive buying movements, and, until some recovery in consumptive demand, markets are likely to remain inactive except from a speculative point of view. Early July sold £168 5s. to £167 10s. end July, £168 to £167 10s. August, £167 10s. to £168, September £168 15s. to £169. English bars were quoted £164. Closing prices :—Cash : Wednesday, £164 ; Thursday, £165 10s. ; Friday, £165 15s. ; Monday, £166 12s. 6d. ; Tuesday, £166 10s. Three Months : Wednesday, £166 15s. ; Thursday, £167 15s. ; Friday, £167 15s. ; Monday, £168 17s. 6d. ; Tuesday, £169.

**Spelter.**—In this section of the metal market the week's business opened with a firm tone, values showing an improvement both for near and forward dates, July metal was sold £27 5s. to £27 12s. 6d., August was quoted £27 15s., and September £27 12s. 6d. to £27 17s. 6d. Closing prices :—Wednesday, £26 12s. 6d. ; Thursday, £26 15s. ; Friday, £27 ; Monday, £28 ; Tuesday, £27.

**Lead.**—The market for soft foreign pig early developed strength, and with sales amounting to about 1,150 tons, Monday's close was firm with June sellers at £23 5s., July £23, August £23, September £23. English lead was dearer at £24 15s. English closing prices : Wednesday, £23 ; Thursday, £23 10s. ; Friday, £24 ; Monday, £24 10s. ; Tuesday, £24 15s.

XUM

## Company News.

**Bell Brothers, Limited.**—Dividend, 15 per cent. per annum, free of tax, for year.

**North Lonsdale Iron & Steel Company, Limited.**—Interim dividend, 2½ per cent.

**Brown, Bayley's Steel Works, Limited.**—Half-year's preference dividend, 5 per cent. per annum, free of tax.

**Millom & Askam Hematite Iron Company, Limited.**—Preference dividend, 3½ per cent.; interim ordinary dividend, 2 per cent., free of tax.

**R. Hood, Haggie & Son, Limited.**—Interim preference dividend, 5 per cent. per annum, less tax; interim ordinary dividend, 10 per cent. per annum, free of tax.

**Burntisland Shipbuilding Company, Limited.**—Special war depreciation, £20,000; brought forward, £17,486; profit, £34,960; dividend for year, 2s. per share, free of tax; carried forward, £7,480.

**Ransomes, Sims & Jefferies, Limited.** — Profit, £15,457; preference dividend to March 31, £11,000; available, £4,457; balance forward, £36,354; directors do not recommend dividend on ordinary for year.

**R. W. Crabtree & Sons, Limited.**—Profit, £1,275; loss, after charging directors' fees, tax and depreciation, £12,056; increased to £98,000 by writing down investment in motor business by £81,981, and providing for preference dividend.

**Stanton Ironworks Company, Limited.**—Final ordinary dividend, 8 per cent., free of tax, making 14 per cent. for year; staff provident fund, £20,000; fire insurance fund, £5,000; workmen's compensation paid, £15,650; carried forward, £136,495

**Edgar Allen & Company, Limited.**—Profit for year, 1921, £42,109; brought forward, £43,568; preference dividend, £15,000; interim ordinary 1s. per share, £20,057; final ordinary dividend, 1s. per share, free of tax, £20,374; carried forward, £30,246.

**Sand, Glass, & Foundry Materials (Amalgamated), Limited.**—Profit, £29,695; set aside for repairs and renewals, depreciation, and directors' fees, £13,074; write off whole of preliminary expenses, £8,426; reserve for wasting assets, £1,000; carry forward, £7,195.

**John Brown & Company, Limited.**—Net profit, £331,920; brought forward, £178,928; interim ordinary dividend, 4 1-6 per cent.; final dividend, 5 5-6 per cent., making 10 per cent. for year, less tax; deb., etc., int., £86,915; pref. div. (5 per cent.), £87,500; carried forward, £179,599.

**Fireclay Products, Limited.**—Capital £5,000 in £1 shares. Registered office: 607, Tower Buildings, Water Street, Liverpool.

**Foundry Equipment & Pattern Company, Limited.**—Capital £500 in 5s. shares. Directors: N. B. Saunders and R. W. Leach. Registered office: Audley Avenue, Newport, Salop.

**Wilmer & Sons, Limited,** ironfounders. — Capital £20,000 in £1 shares. Registered office: 13/14, Bury Street, E.C.

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MR. A. RAMSAY, of Ruston & Hornsby, Limited, has been elected chairman of the Birmingham and District Employers' Federation.

THE K.S.M. ENGINEERING COMPANY, LIMITED, are being wound up voluntarily. Mr. H. V. Thurgood, 11, Queen Victoria Street, London, E.C., has been appointed liquidator.

THE FIRST MEETINGS of the creditors and contributories of the Pullinger Engineering Company, Limited, Giltspur Chambers, 52, Holborn Viaduct, London, E.C., was held on June 29.

## Personal.

THE LATE MR W. HAINS, engineer, Westleigh, Richmond Place, Blackpool, left £20,649.

MR. BENJAMIN WINCHESTER, of Glasgow, late secretary of the North British Locomotive Company, Limited, left £10,151.

DR. G. RUTTER, deputy-director of research at the Royal Arsenal, Woolwich, has been appointed director of research in succession to SIR ROBERT ROBERTSON.

PROF. J. A. FLEMING has been awarded the Albert Medal of the Royal Society of Arts for 1921, in recognition of his many valuable contributions to electrical science and its application, and specially of his original invention of the thermionic valve, now so largely employed in wireless telegraphy.

MR. CHARLES ALDINGTON, the Great Western Railway Company's general manager, has felt it necessary to resign his position on account of ill-health, and he will be succeeded by MR. F. J. C. POLE, who has for two years been the assistant general manager, and taken the place of his chief during the latter's absence.

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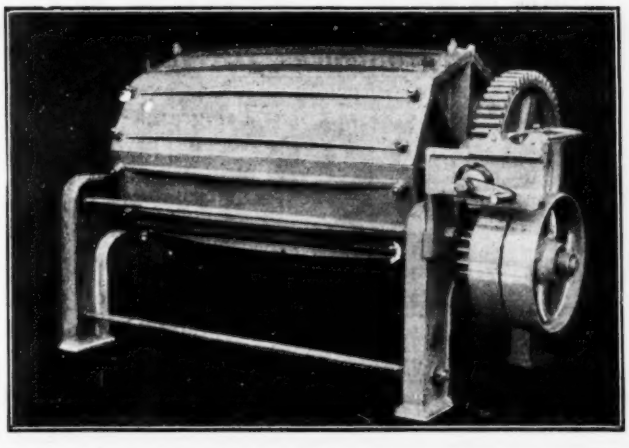

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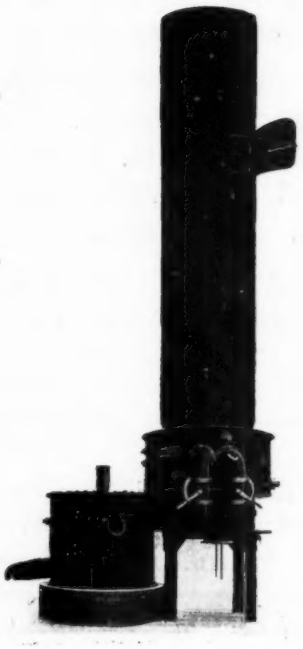

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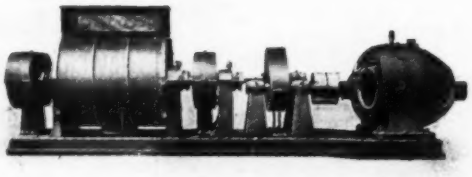

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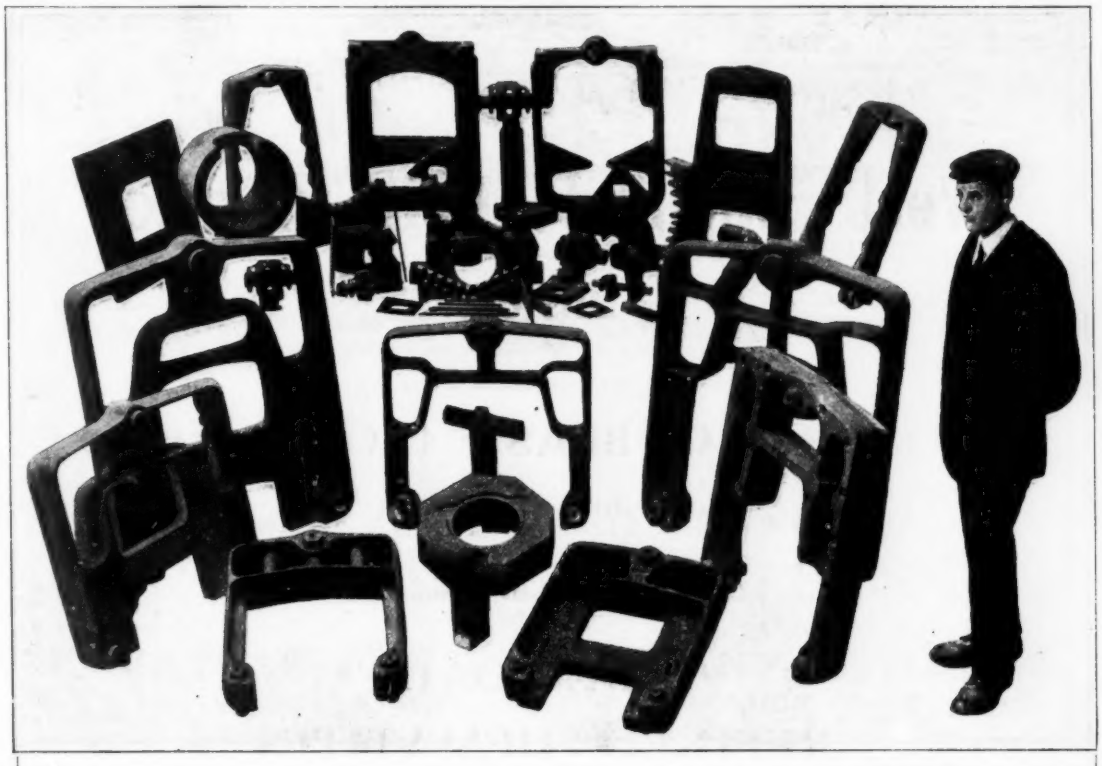

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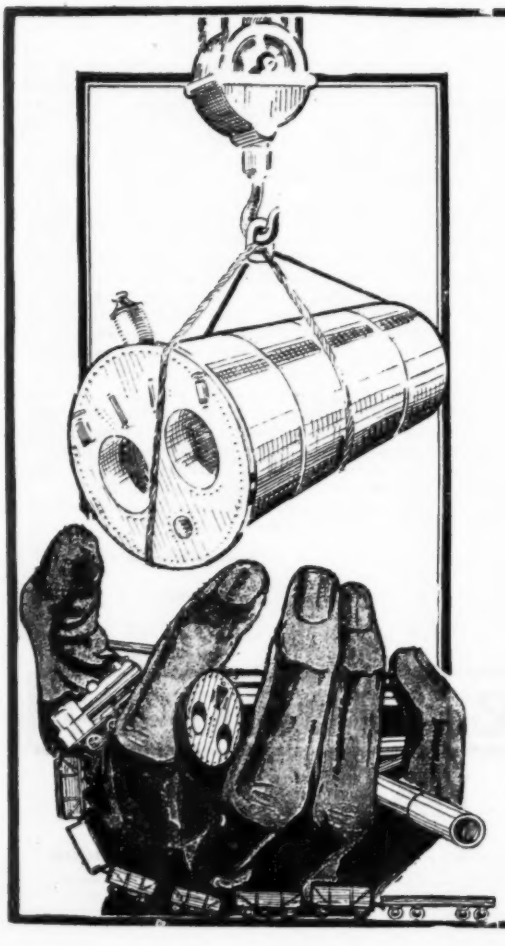

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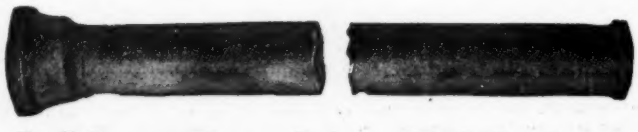

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| Three months | 70 | 12 | 6 |
| Electrolytic | 74 | 0 | 0 |
| Tough | 71 | 0 | 0 |
| Best selected | 71 | 5 | 0 |
| Sheets | 112 | 0 | 0 |
| India | 112 | 0 | 0 |
| Wire bars | 75 | 10 | 0 |
| Do. July | 75 | 10 | 0 |
| Do. Aug. | 75 | 10 | 0 |
| Ingot bars | 75 | 0 | 0 |
| H.C. wire rods | 82 | 0 | 0 |
| Off. aver. cash, May | 73 | 5 | 10½ |
| Do. 3 mths., May | 72 | 11 | 1 |
| Do. Settlement May | 73 | 5 | 2½ |
| Do. Electro, May | 74 | 15 | 8½ |
| Do. B.S., May | 74 | 1 | 8 |
| Aver. spot, copper, May | 73 | 5 | 2¾ |
| Do. Electro, May | 75 | 6 | 2¼ |
| Solid drawn tubes | | 15½d. | |
| Brazed tubes | | 15½d. | |
| Wire | | 11¼d. | |
| Yellow metal rods | | 8½d. | |
| Do. 4x4 Squares | | 10d. | |
| Do. 4x3 Sheets | | 10d | |

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| Brazed tubes | 16½d |
| Rods | 12½d. |
| Sheets to 10 w.g. | 11¾d. |
| Wire | 11⅝d. |
| Rolled metal | 11¼d. |

## TIN.

| | £ | s. | d |
|---|---|---|---|
| Standard cash | 166 | 10 | 0 |
| Three Months | 169 | 0 | 0 |
| English | 165 | 0 | 0 |
| Bars | 167 | 0 | 0 |
| Chinese | 162 | 15 | 0 |
| Straits | 167 | 10 | 0 |
| Australian | 167 | 15 | 0 |
| Eastern | 169 | 10 | 0 |
| Banca | 171 | 15 | 0 |
| Off. aver., cash, May | 177 | 10 | 8½ |
| Do. 3 mths., May | 178 | 19 | 10½ |
| Do. Sttlment., May | 177 | 9 | 0½ |
| Aver. spot, May | 177 | 8 | 4 |

## SPELTER.

| | £ | s. | d |
|---|---|---|---|
| Ordinary | 27 | 0 | 0 |
| Remelted | 23 | 5 | 0 |
| Hard | 17 | 0 | 0 |
| Electro 99.9 | 36 | 10 | 0 |
| English | 34 | 0 | 0 |
| India | 21 | 10 | 0 |
| Prime Western | 29 | 0 | 0 |
| Zinc dust | 45 | 0 | 0 |
| Zinc ashes | 6 | 0 | 0 |
| Off. aver., May | 27 | 6 | 7½ |
| Aver., spot, May | 26 | 18 | 5½ |

## LEAD.

| | £ | s. | d |
|---|---|---|---|
| Soft foreign ppt | 23 | 12 | 6 |
| English | 24 | 15 | 0 |
| Off. average, May | 23 | 7 | 3¾ |
| Average spot, May | 23 | 7 | 8¾ |

## ZINC SHEETS.

| | £ | s. | d |
|---|---|---|---|
| Zinc sheets, spot | 35 | 0 | 0 |
| Do. V.M. ex. whf | 35 | 0 | 0 |
| Do. ppt., f.o.b., N.Y. | | — | |
| Dutch | 35 | 0 | 0 |
| Boiler plates | 33 | 0 | 0 |
| Battery plates | 32 | 10 | 0 |

## ANTIMONY.

| | £ | s. | d |
|---|---|---|---|
| English regulus | 37 | 0 | 0 |
| Special brands | 42 | 0 | 0 |
| Chinese | 25 | 0 | 0 |
| Crude | 18 | 0 | 0 |

## QUICKSILVER.

| | £ | s. | d |
|---|---|---|---|
| Quicksilver | 10 | 17 | 6 |

## FERRO-ALLOYS AND STEEL-MAKING METALS.

| | |
|---|---|
| Ferro-silicon— | |
| 45/50% | £15 10 0 |
| 75% | £22 0 0 |
| Ferro-vanadium— | |
| 35/40% | 22/- lb. va. |
| Ferro-molybdenum— | |
| 70/80% | 10/- lb. mo. |
| Ferro-titanium— | |
| 23/25%, carbonless | 1/6 lb. |
| Ferro-phosphorus, 20/23% | £29 |
| Ferro-tungsten— | |
| 80/85%, carbon free | 1/9 lb. |
| Tungsten metal powder— | |
| 98/99% | 2/1 lb. |
| Ferro-chrome— | |
| 4/6% car. | £37 |
| 6/8% car. | £36 |
| 8/10% car. | £35 10 |
| Ferro-chrome— | |
| Max. 2% car. | £82 |
| Max. 1% car. | £98 |
| Max. 0.75% car. | £118 |
| 65/75%, carbonless | 2/9 lb. |
| Nickel—99·8%, cubes or pellets | £185 |
| Cobalt metal—97% | 15/- lb. |
| Aluminium—98/99% | £150 |
| Metallic Chromium— | |
| 98/99% | 6/- lb. |
| Ferro-manganese— | |
| 76/80%, loose | £18 |
| 76/80%, packed | £19 |
| 76/80%, export | £15 |
| Metallic manganese— | |
| 98/99%, carbonless | 2/10 lb. |

Per ton unless otherwise stated.

## HIGH-SPEED TOOL STEEL.

| | s. | d. |
|---|---|---|
| Finished bars, 14% tungsten | 3 | 0 |
| Finished bars, 18% tungsten | 3 | 9 |
| Scrap pieces | | 5d. |
| Turnings and swarf | | 3d. |

Per lb. net, d/d buyers' works.

Extras—

| | |
|---|---|
| Rounds and squares 3 in. to 8 in. inclusive | 4d. lb. |
| Rounds and squares under ½ in. to ¼ in. | 3d. lb |
| Flats under 1 in. by ⅜ in. to ½ in. by ¼ in., and all sizes over four times in width over thickness | 3d. lb. |
| Bevels of approved sizes and sections | 6d. lb. |
| If in coils | 3d. lb. |
| Packing | 4s. cwt |

Bars cut to length 10% extra

Scrap from high-speed tool steel—

| | |
|---|---|
| Scrap pieces | 5d. |
| Turnings and swarf | 3d. |

Per lb. net, d/d steel makers' works.

## SCRAP.

| South Wales—£ s. d. | £ | s. | d. |
|---|---|---|---|
| Heavy Steel | 3 | 10 | 0 |
| Bundled steel & shearings | 2 | 15 | 0 |
| Mixed iron & steel | 1 0 0 | 4 | 0 0 |
| Heavy cast iron | 3 | 10 | 0 |
| Good machinery for foundries | 5 | 10 | 0 |
| Cleveland— | | | |
| Heavy steel | 2 | 10 | 0 |
| Steel turnings | 2 | 5 | 0 |
| Cast-iron borings | 2 | 5 | 0 |
| Heavy wrought iron piling | 2 | 15 | 0 |
| Bundling scrap | 4 | 0 | 0 |
| Cast-iron scrap | 5 | 10 | 0 |
| Lancashire— | | | |
| Cast iron scrap | 6 | 10 | 0 |
| Heavy wrought | 3 | 0 | 0 |
| Steel turnings | 1 | 10 | 0 |
| London— | | | |
| Copper (clean) | 53 | 0 | 0 |
| Brass (clean) | 30 | 0 | 0 |
| Lead (less usual draft) | 18 | 0 | 0 |
| Tea lead | 16 | 0 | 0 |
| Zinc | 12 | 0 | 0 |
| New aluminium cuttings | 70 | 0 | 0 |
| Braziery copper | 43 | 0 | 0 |
| Gun metal | 45 | 0 | 0 |
| Hollow pewter | 135 | 0 | 0 |
| Shaped black pewter | 80 | 0 | 0 |

## PIG-IRON.

(Premiums required for foundry).

| | |
|---|---|
| N. E. Coast— | |
| Foundry No. 1 | 125/- |
| Foundry No. 3 | 120/- |
| Forge No. 4 | 117/6 |
| Mottled | 117/6 |
| Hematite No. 1 | 162/6 |
| Hematite M/Nos. | 160/- |
| Midlands— | |
| Staffs. common | 145/- |
| „ part-mine forge | 160/- |
| „ „ foundry | 170/- |
| „ Cold blast | 320/- |
| „ basic | 140/- |
| Northants forge | 140/- |
| „ foundry No. 3 | 147/6 |
| „ basic | 140/- |
| Derbyshire forge | 150/- |
| „ foundry No. 3 | 160/- |
| „ basic | 150/- |
| Scotland— | |
| Foundry No. 1 | 175/- |
| „ No. 3 | 170/- |
| Hematite M/Nos. | 180/- |
| Sheffield (d/d district)— | |
| Derby forge | 155/- |
| „ foundry No. 3 | 160/- |
| „ basic | 155/- |
| Lincs. forge | 160/- |
| „ foundry No. 3 | 170/- |
| „ basic | 162/6 |
| E.C. hematite | 173/- |
| W.C. hematite | 176/- |
| All d/d in the district. | |
| Lancashire (d/d eq. Man.)— | |
| Derby forge | — |
| „ foundry No. 3 | 170/- |
| Northants foundry No. 3 | — |
| Cleveland foundry No. 3 | — |
| Staffs. foundry No. 3 | — |
| Lincs. forge | 172/6 |
| „ foundry No. 3 | 177/6 |
| Summerlee foundry | 195/6 |
| Glengarnock foundry | 198/- |
| Gartsherrie foundry | 195/6 |
| Monkland foundry | 195/6 |

## FINISHED IRON & STEEL.

| Iron— | £ | s. | d. |
|---|---|---|---|
| Bars (crown) | 16 | 0 | 0 |
| Angles | 16 | 10 | 0 |
| Tees to 3 united ins. | 17 | 0 | 0 |
| Nut and bolt | 16 | 0 | 0 |
| Hoops | 20 | 5 | 0 |
| Marked bars (Staffs.) | 22 | 0 | 0 |
| Gas strip | 22 | 0 | 0 |
| Bolts and nuts, ¾ in. × 4 in. | 35 | 0 | 0 |
| Steel— | | | |
| Ship plates | 15 | 0 | 0 |
| Boiler plates | 21 | 0 | 0 |
| Checquer plates | 16 | 0 | 0 |
| Angles | 14 | 10 | 0 |
| Tees | 15 | 10 | 0 |
| Channels | 14 | 15 | 0 |
| Joists | 14 | 10 | 0 |
| Rounds, ¾ in.–3-in. | 14 | 0 | 0 |
| Rounds, 3 in.–5½ in. | 13 | 10 | 0 |
| Flats, 5 in.–8 in. | | — | |
| Flats over 8 in. | 15 | 0 | 0 |
| Rails, heavy | 15 | 0 | 0 |
| Fishplates | 20 | 0 | 0 |
| Hoops | 16 | 10 | 0 |
| Black sheets, 24 g. | 19 | 10 | 0 |
| Galv. cor. sheets, 24 g. | 22 | 0 | 0 |
| Galv. fencing wire, 8 g. plain | 23 | 10 | 0 |
| Rivets, ¾ in. dia | 27 | 0 | 0 |
| Billets, soft | 10 | 10 | 0 |
| Billets, hard | 11 | 10 | 0 |
| Sheet and tin bars | 10 | 10 | 0 |

## PHOSPHOR BRONZE.

| Rolled. | Per lb. s. | d. |
|---|---|---|
| ¼ in. to 1 in. wide | 1 | 8¾ |
| 1 in. to 1½ in. wide | 1 | 8½ |
| 1½ in. to 2 in. wide | 1 | 6¾ |

| Strips. | s. | d |
|---|---|---|
| 2 in. to 6 in. to 26 S.W.G. | 1 | 6¼ |
| 6 in. to 12 in. to 26 S.W.G. | 1 | 6¼ |

| Sheets. | | |
|---|---|---|
| 12 in. to 18 in. to 24 S.W.G. | 1 | 6¼ |
| 18 in. to 24 in. to 24 S.W.G. | 1 | 7¼ |
| 24 in. to 30 in. to 20 S.W.G. | 1 | 8¼ |
| 30 in. to 36 in. to 16 S.W.G. | 1 | 9¼ |
| 36 in. to 42 in. to 16 S.W.G. | 1 | 9¼ |

Extras.

For Gauge: Any width up to 36 in. wide, ¼d. per lb. per thinner gauge.

| Drawn Rods. | s. | d. |
|---|---|---|
| ¼ in. to ½ in. dia. in random lengths; ⅝ in. to 1¼ in. dia. in random lengths | 1 | 6 |
| Over 1¼ in. to 1⅝ in. | 1 | 6 |
| Tubes—basis price | 1 | 8¼ |

Delivery 3 cwt. free to any town.

10% phosphor copper, £40 above price of B.S.

15% phosphor copper, £50 above price of B.S.

Phosphor tin (5%), £30 above price of English ingots.

Charles Clifford & Son, Limited, Birmingham.

## NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

| | Per lb. |
|---|---|
| Ingots for raising | 1/1 to 1/7 |
| Rolled— | |
| To 9 in. wide | 1/8½ to 2/2½ |
| To 12 in. wide | 1/9 to 2/3 |
| To 15 in. wide | 1/10 to 2/4 |
| To 18 in. wide | 1/11 to 2/5 |
| To 21 in. wide | 2/- to 2/6 |
| To 24 in. wide | 2/1 to 2/7 |
| Ingots for spoons and forks | 1/1 to 1/7 |
| Ingots rolled to spoon size | 1/4 to 1/10 |
| Wire round— | |
| 3/0 to 10. G. | 1/11 to 2/6 |

with extras according to gauge.

## AMERICAN IRON & STEEL.

| At Pittsburgh unless otherwise stated. | Dols. |
|---|---|
| No. 2X foundry, Phila. | 25.50 |
| No. 2 foundry Valley | 22.50 |
| No. 2 foundry, Birm. | 20.00 |
| Basic | 22.96 |
| Bessemer | 24.96 |
| Malleable | 24.96 |
| Grey forge | 23.46 |
| Ferro-manganese 80 % delivered | 75.00 |
| Bess. rails, h'y, at mill | 45.00 |
| O.-h. rails, h'y, at mill | 47.00 |
| Bess. billets | 37.00 |
| O.-h. billets | 37.00 |
| O.-h. sheet bars | 39.00 |
| Wire rods | 48.00 |
| | Cents. |
| Iron bars, Phila. | 2.25 |
| Steel bars | 2.10 |
| Tank plates | 2.00 |
| Beams, etc. | 2.20 |
| Skelp, grooved steel | 2.10 |
| Skelp, sheared steel | 2.10 |
| Steel hoops | 2.75 |
| Sheets, black, No. 28 | 3.75 |
| Sheets, galv., No. 28 | 4.75 |
| Sheets, blue an'l'd, 9&10 | 2.85 |
| Wire nails | 3.00 |
| Plain wire | 2.75 |
| Barbed wire, galv. | 3.85 |
| Tinplate, 100-lb. box | $6.25 |

## COKE.

| | |
|---|---|
| Welsh foundry | 67/6 |
| „ furnace | 55/- |
| Durham & North. foundry | 70/- |
| „ furnace | 42/6 |
| Other Districts, foundry | 77/9 |
| „ furnace | 45/- |

### SWEDISH IRON.

Bars, hammered basis sizes Basis price £31 to £32

| | £ s. d. |
|---|---|
| Rolled Ordinary— Assortment .. | 22 10 0 to 23 10 0 |
| Nail Rods— Square, round and flats .. | |
| Keg Steel | £38 to £40 |
| Faggot Steel | £30 to £32 |
| Blooms— Single welded | £16 to £18 |
| Billets— Single and double welded | £18 to £20 |
| Pig-Iron— Grey, white or mottled | £10/10 to £11 10 |

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

### TUBES.

| | Up to and incl. 2 in. | Over 2 in. |
|---|---|---|
| Gas .. | −25% | −30% |
| Water .. | −15% | −21¼% |
| Steam .. | − 3¾% | −11¼% |

### TINPLATES.

| | | |
|---|---|---|
| I.C. Cokes, | 20×14, box | 25/- |
| „ | 28×20, „ | 51/- |
| „ | 20×10, „ | 35/- |
| „ | 18¾×14, „ | 29/- |
| I.X. | „ | 64/- |
| I.X.X. | „ | 84/- |
| F.C.B.Y. | 21×13⅝ „ | 48/6 |
| C.V.B.G. | 16½×15, „ | 49/- |
| I.C.W. | 20×14, „ | 20/- |
| „ | 28×20, „ | 40/- |
| „ | 20×10, „ | 22/9 |
| „ | 18¾×14, „ | 16/6 |
| Terneplates, | 28×20, „ | 53/- |

### DAILY FLUCTUATIONS.

**Standard Copper** (cash).

| | £ | s. | d. | | |
|---|---|---|---|---|---|
| June 22 | 70 | 5 | 0 | dec. | 7/6 |
| „ 23 | 69 | 12 | 6 | „ | 12/6 |
| „ 24 | 69 | 7 | 6 | „ | 5/- |
| „ 27 | 70 | 12 | 6 | inc. | 25/- |
| „ 28 | 70 | 5 | 0 | dec. | 7/6 |

**Electrolytic Copper**

| | | | | | |
|---|---|---|---|---|---|
| June 22 | 74 | 0 | 0 | dec. | 20/- |
| „ 23 | 74 | 0 | 0 | No change | |
| „ 24 | 73 | 10 | 0 | dec. | 10/- |
| „ 27 | 74 | 0 | 0 | inc. | 10/- |
| „ 28 | 74 | 0 | 0 | No change | |

**Standard Tin** (cash).

| | | | | | |
|---|---|---|---|---|---|
| June 22 | 164 | 0 | 0 | dec. | 10/- |
| „ 23 | 165 | 10 | 0 | inc. | 30/- |
| „ 24 | 165 | 15 | 0 | „ | 5/- |
| „ 27 | 166 | 12 | 6 | „ | 17/6 |
| „ 28 | 166 | 10 | 0 | dec. | 2/6 |

**Tin** (English Ingots)

| | | | | | |
|---|---|---|---|---|---|
| June 22 | 162 | 10 | 0 | inc. | 10/- |
| „ 23 | 163 | 0 | 0 | inc. | 10/- |
| „ 24 | 163 | 10 | 0 | „ | 10/- |
| „ 27 | 164 | 0 | 0 | „ | 10/- |
| „ 28 | 165 | 0 | 0 | „ | 20/- |

**Zinc Sheets** (spot).

| | | | | | |
|---|---|---|---|---|---|
| June 22 | 35 | 0 | 0 | dec. | 20/- |
| „ 23 | 35 | 0 | 0 | No change | |
| „ 24 | 35 | 0 | 0 | No change | |
| „ 27 | 35 | 0 | 0 | No change | |
| „ 28 | 35 | 0 | 0 | No change | |

**Spelter** (ordinary).

| | | | | | |
|---|---|---|---|---|---|
| June 22 | 26 | 12 | 6 | dec. | 2/6 |
| „ 23 | 26 | 15 | 0 | inc. | 2/6 |
| „ 24 | 27 | 0 | 0 | inc. | 5/- |
| „ 27 | 28 | 0 | 0 | „ | 20/- |
| „ 28 | 27 | 0 | 0 | dec. | 20/- |

**Lead** (English).

| | | | | | |
|---|---|---|---|---|---|
| June 22 | 23 | 0 | 0 | No change | |
| „ 23 | 23 | 10 | 0 | inc. | 10/- |
| „ 24 | 24 | 0 | 0 | „ | 10/- |
| „ 27 | 24 | 10 | 0 | „ | 10/- |
| „ 28 | 24 | 15 | 0 | „ | 5/- |


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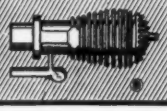
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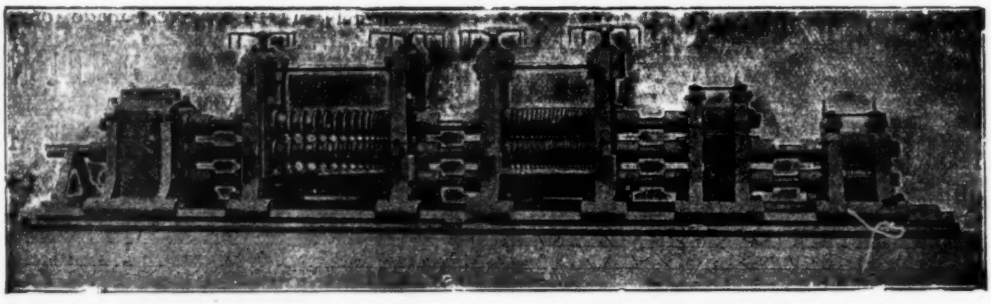

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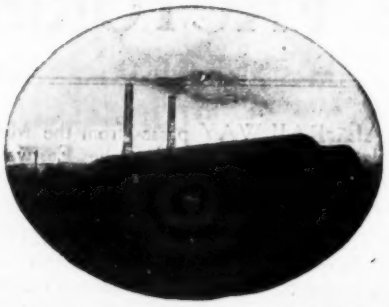

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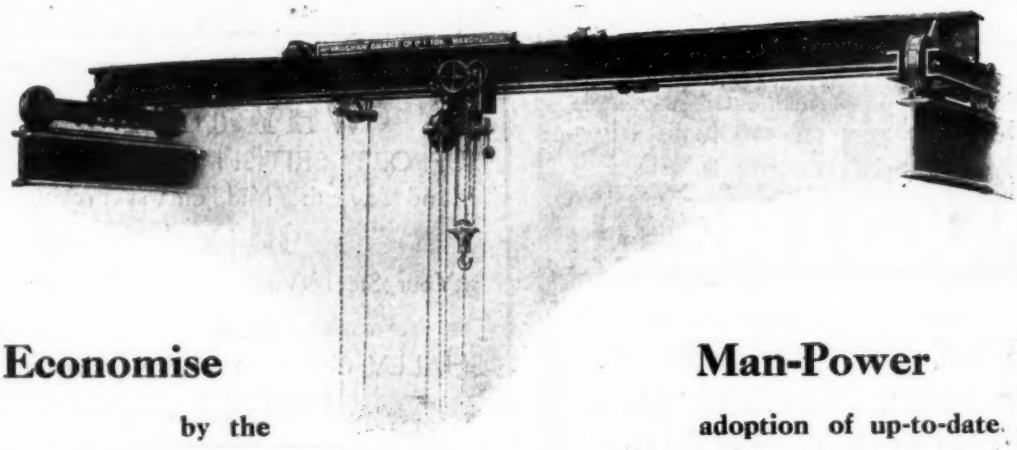

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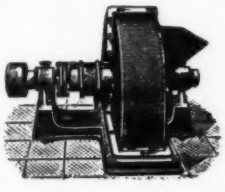

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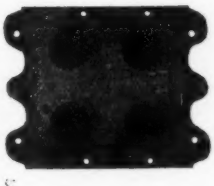

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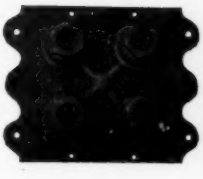

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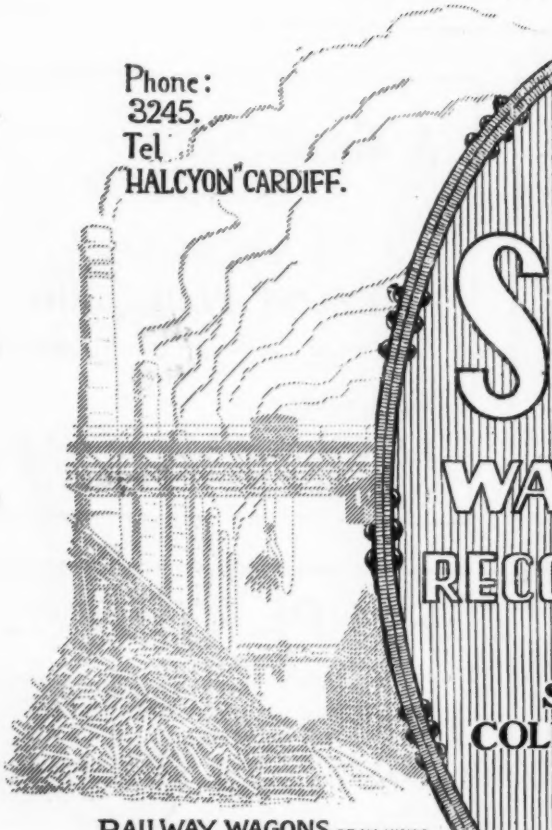

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